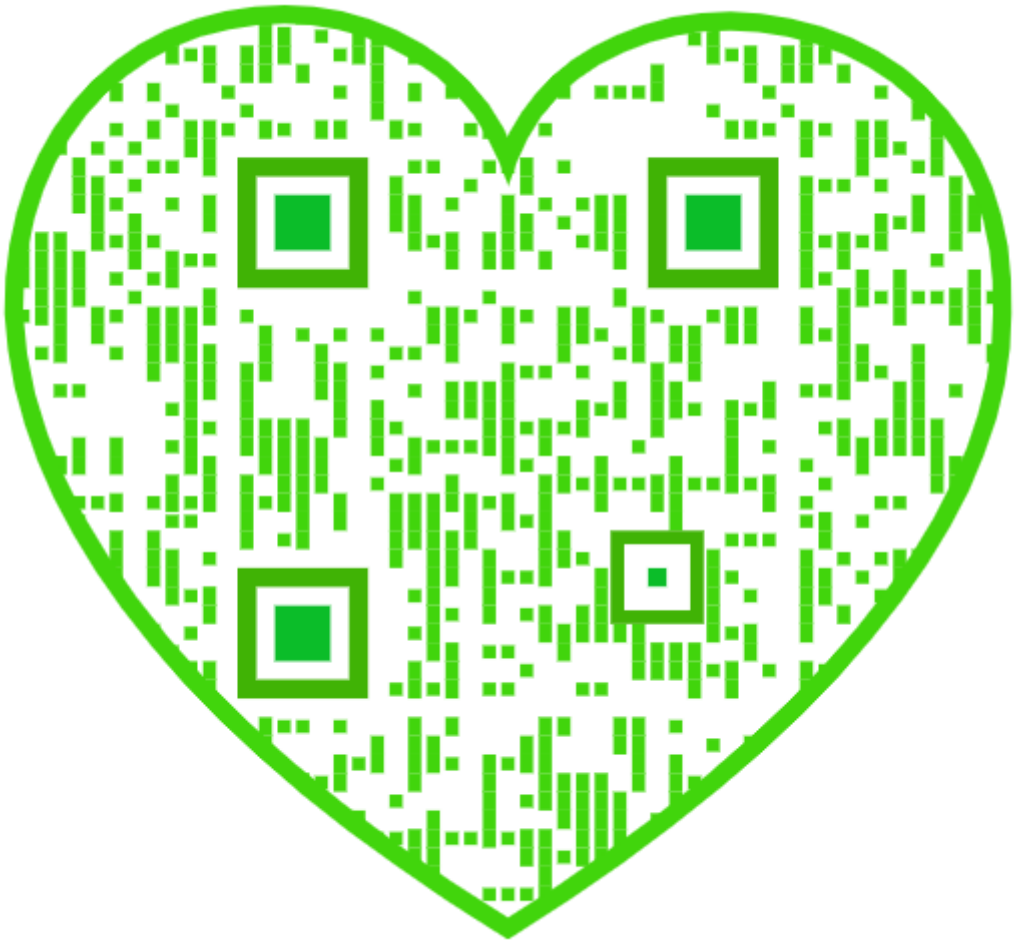
THE COTTON FIBRE AND THE MIXING OF COTTON.

BY

HUGH MONIE, JR.



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HUGH MONIE, Junr.

(Author of "The Cotton Fibre, its Structure, Etc.;" "Mixing;" "Sizing Ingredients, Sizing, Etc.").

General Editor "The Electrical, Mechanical and Textile News."

Principal Victoria Jubilee Technical Institute (Bombay).

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PREFACE TO 1904 EDITION.

With the development of Technical Education, a revised and extended edition of this work has been called for.

The Author feels complimented to note that in the books on Cotton Spinning which have appeared within the last few years, copious extracts from the last edition have been made.

In addition to making necessary additions and corrections, the Author has thought it advisable to introduce a special section on the MIXING OF COTTONS. Hitherto in all works on cotton or cotton spinning the very important subject of cotton mixing has either been entirely omitted or treated most superficially. Everyone connected with the industry will at once admit that the marring or making of a mill lies largely in the mixing room, and this extension of the work will be found to be of value to those interested.

To include this new chapter, the title of the book has been slightly changed.

Since the first edition was published the Author's experience has extended to the manufacturing districts of India and the Continent, where a special study of the subject has been possible.

THE

STRUCTURE

OF THE

COTTON FIBRE.

CHAPTER I.

1.—In the various cotton markets of the world the different supplies of cotton are generally known by the names of the district in which they have been grown. In some cases this is misleading, because it has many times been found that supplies carrying a certain mark were doing so fraudulently. The mark had been given to the bales either at the port of shipment or at the district where ginning and baling had been done, and not that of the district of growth.

All geographical descriptions of cotton are largely subdivided into varying grades in order to facilitate the work of selection at the distributing centres.

These are :—

American.—Middling Fair, Fully Good Middling, Good Middling, Middling, Low Middling, Good Ordinary, and Ordinary.

Egyptian.—Extra Fine, Fine, Good, Fully Good Fair, Good Fair, Fair, Middling Fair, and Middling.

Indian.—Fine, Good, Good Fair, and Fair.

Brazilian.—Fine, Good, Good Fair, Fair, Middling Fair and Middling.

Sometimes and particularly in dealing with American Cottons, other distinctive expressions are used to indicate intermediate variations of grade. Thus :—

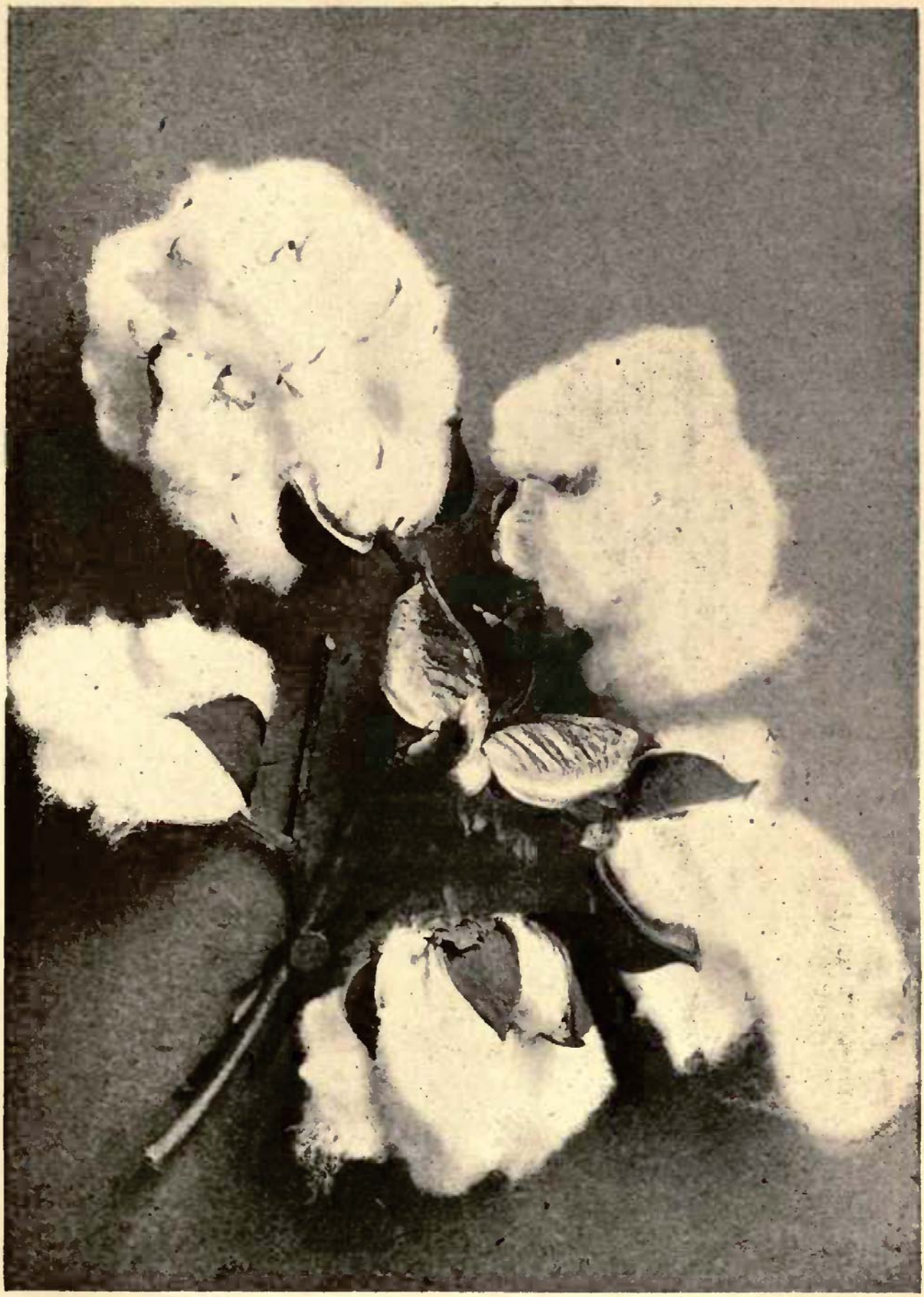
"Barely" means a quarter lower in quality than a full grade.

"Fully" means a quarter grade higher.

"Strict" means half a grade higher.

2.—Each distributing district has its own system of trading in cotton, although there are many points in common. In Liverpool the buying and selling are effected through the agency of brokers, the *selling* broker acting in place of the merchant, and the *buying* broker on behalf of the spinner's representative. There is thus no direct connection between the user and the supplier, and each side has to pay one-half per cent commission to its representative broker.

All claims as regards fraudulent packing, or marking of the bales are made by the spinner through the buying broker.



COTTON BOLLS

(From a Photograph by Mr. H. Garside, Manchester.)

Each lot of cotton is bought from standard samples kept in the office of the buying broker, and these samples are supposed to fairly represent the characteristics of the cotton in bulk.

The terms of purchase are generally 1½ per cent net discount for payment within ten days and a rebatement at the rate of 5 per cent per annum for the number of days the cotton is paid for before the expiration of that period. Payment made later than the ten days' concession carries an increase at the same rate as the rebatement.

Fluctuations in the price of cotton are generally described as a rise of one or more "points." In England this point is $\frac{1}{64}$th of a penny per lb.

The great commercial division of the cottons of commerce comprises the following in order of quality:—

Sea Island,
Egyptian,
Brazilian and Peruvian,
American,
Indian.

In order of quantity the rotation is:—

American,
Indian,
Egyptian,
Brazil and Peruvian,
Sea Island.

3.—These cottons are packed in bales, the weights of which vary very considerably. This will be seen from the following comparative statement:—

CLASS.	No. of iron hoops or bands on the bale.	Approximate weight of bands in lb.	Weight of pressed bales in lb.	Measurement of bales in feet.
American	7	8 to 16	300 to 870	$4\frac{1}{2} \times 3\frac{1}{3} \times 2\frac{1}{4}$
Egyptian	11	17	670 to 840	$4\frac{1}{4} \times 2\frac{7}{12} \times 1\frac{5}{6}$
Indian ...	3 (passing 3 times round)	4	340 to 500	$4\frac{1}{12} \times 1\frac{5}{6} \times 1\frac{1}{3}$
Brazil ...	2	6	360 to 430	$4\frac{1}{12} \times 1\frac{5}{6} \times 1\frac{1}{2}$
Peruvian	very irregular in all particulars.			

Pressed bales are those which are compressed into the above limits by hydraulic pressure but half pressed bales, particularly from South America, are also received. The dimensions of the latter may be anything up to three times the above. They are not bound by iron bands but by ropes, and the pressing is done in hand screw presses.

All cotton, with the exception of the American, is covered with strong canvas which protects the cotton from injury, but with the American, a loosely woven bagging cloth is used. This is weak and easily torn, so that American bales are always landed in a much more ragged condition than the others. The economy in the cost of the covering—if economy it is—is a false one in the long run, and it is surprising that energetic America does not make some improvement in the matter.

The chief Ports for the distribution of cotton, are:—

New York, New Orleans, and Charleston for America.
Liverpool and to some extent Manchester for England.
Bremen for Germany.
Havre for France.
Amsterdam for Holland.
Alexandria for Egypt.
Bombay for India.

The chief classes of cotton used by these countries, are :—

America .....American.
England .....American and Egyptian.
Germany .....American (some Indian).
France.....Indian.
Holland .....Indian.
India .....Indian.

4.—The magnitude of the deliveries of cotton in the manufacturing countries is beyond mental conception. Last season (June, 1903) they were :—

	American	Indian	Brazilian	Egyptian	Sundry
Gt. Britain	2,603,000	69,000	160,000	337,000	40,000 b'les
Continent	3,946,000	1,146,000	118,000	318,000	61,000 „

The equivalents of these totals are 3,209,000 bales for Great Britain, and 5,589,000 for the whole of the Continent.

The American total crop for season 1903 (June) amounted to 11,415,000 bales of 450 lbs. net, while the world's total was 16,104,000 bales.

The world's consumption of various cottons at the present time averages about:—

American	10,286,000 bales.
Indian	1,854,000 „
Egyptian	791,000 „
Sundries	339,000 „
	13,270,000 bales.

If the bales are calculated at 500 lbs. each, the equivalent will be reduced to about 12,500,000 bales.

It is interesting to note that in Great Britain the consumption of American cotton has remained practically stationary for the past six years, although fluctuating somewhat. That of Indian has increased by nearly 50 per cent, Brazilian by nearly 75 per cent, Egyptian stationary, and Sundries stationary.

On the Continent the consumption of American has declined, Indian increased by over 25 per cent, Brazilian stationary, Egyptian decreased by about 10 per cent, and Sundries show a slight increase.

5.—Tabulated Statement of Commercial Cottons and Districts of Cultivation.

Variety of Cotton.	Country or District.
Sea Island.....	*North America.*—On the coast of Florida, Georgia, South Carolina, and Bahama Islands.

Florida Sea Island..... *North America.*—On the Florida mainland.

Gallini..... *Egypt.*—Along the course of the Nile, Messifieh, &c.

Fiji Sea Island..... *Fiji or Viti Islands.*—In the South Pacific.

Tahiti Sea Island..... *Polynesia.*— The Society Islands, Marquesas Islands, &c.

Australian Sea Island... *Queensland.*— Along the shores of the South Pacific.

Peruvian Sea Island..... *Peru.*—Lima, and along the Western shores.

Brown Egyptian ..... *Egypt.*—In the delta of the Nile and along a considerable portion of its course Southwards at Zagazig, Mansurah, Behara.

Rough Peruvian ..... *South America.*—In various parts of Peru, but chiefly in the vicinity of the sea coast.

Smooth Peruvian..... *South America.*—In various parts of Peru, but chiefly in the vicinity of the sea coast.

White Egyptian..... *Egypt.*—In the Nile delta, and in various parts of Lower Egypt, Ziftah, &c.

Pernambuco—Brazil..... *South America.*—At Pernambuco and vicinity.

Maranhams—Brazil..... *South America.*—At Maranhao and N.E. coast of Brazil.

Ceara—Brazil..... *South America.*—In the district of Ceara.

Bahia—Brazil..... *South America.*—In the district of San Salvador.

Orleans—American. .... *United States.*—Chiefly in Mississippi and Louisiana.

Texas—American..... *United States.*—In different parts of the States of Texas, but chiefly in the vicinity of the Gulf of Mexico.

Upland—American ..... *United States.*—In the northern parts of Alabama, Georgia, South Carolina, and in the Southern parts of Tennessee.

Mobile—American ..... *United States.*—In various parts of the States of Alabama, Mississippi, and Louisiana.

Maceio—Brazilian..... *South America.*— In the plantations of Allagoas, Maceio, &c.

Paraiba .... *South America.*— In the plantations of the Eastern coast of Brazil.

Santos..... *South America.*—Along the South-Eastern coast of Brazil.

Smyrna..... *Asiatic Turkey.*—In the plantations on the Western coast.

West Indian .... *West Indian Islands.*—At Cuba, Dominica, Jamaica and many of the smaller of these Islands.

Natal or African..... *Africa.*—On the plantations of the South-Eastern shores of Natal, and the Western coast of the State of Upper Guinea, round Liberia.

6.—As so little is actually known amongst spinners in England as to the qualities and spinning resources of Indian cottons, the following might be studied with advantage. Doing so might also suggest the advisability of a special enquiry into the values of the distinctive varieties with a view of finding supplies capable of producing a yarn equal to what they are now doing and at a cheaper rate.

Indian cottons as landed in England are *not at all* representative of any particular district of growth, a fact which will come as a surprise to a large nnmber of users.

Hingunghat.—The growth known by this name is produced in the Central Provinces named after the town of Hingunghat.

Broach and Surat.—The principal districts under this heading are Broach, Baroda (Naosari and Baroda districts), Surat Rewa-Kantha, Panchmahal, and the remaining Surat States.

Madras.—Four different descriptions of cotton are cultivated in the Madras Presidency :—Westerns, Coconadas, Tinnevellys, and Salems or Coimbatores. "Westerns" are also grown in the greater portion of Nizam's dominions, especially to the south.

Dholleras.—These are produced in the Native States of Kathiawar, Ahmedabad, Cutch, Baroda districts of Kadi and Amreli Palanpur, Mahi-Kantha, Kaira and Cambay. In Kathiawar, especially in Mowa, a short stapled variety of cotton of early growth, originally produced from Bengal seed, is grown, which is called "Mathia Cotton," whilst another variety, grown from Cawnpore seed, is designated by the name of "Karni."

Oomras.—Though this growth is now divided into three subdivisions in Liverpool, viz. :—Oomras, Khandeish, and Bilatee, the distinguishing landmarks to Bombay are the districts of production, *i.e.*, Berar, Khandeish, and Barsi-Nugger. The best description of Oomras is the production of Berar, known officially as the "Hyderabad Assigned Districts." Khandeish is produced in the district of that name, and to a small extent also in Nassick. Barsi and Nugger descriptions are named after the towns of Barsi and Ahmednagar, through which the bulk of the cotton passes, but the greater portion of the staple is produced in the Northern portion of the Nizam's territory.

Comptas and Dharwars.—Both are received from the same districts, Bijapore, Dharwar, Belgaum, Kolhapore, and Southern Mahratta States.

Bengals.—Of this short stapled variety more is produced than of any other growth in India. Under this heading are included Bengal, N.W. Provinces and Oudh, Central India, Rajpootana, Punjab and Sindh. Although the Province of Bengal gives its name to the most extensively grown of all Indian cottons, the actual cultivation within its borders is extremely small. In the various Native States comprised under the heading of the Central India Agency, principally "Bengals," and to a smaller extent "Oomras," are produced.

7.—The cotton plant in the various countries of cultivation present certain differences and characteristics which are more or less apparent, but it is in the product of the plant—the fibres themselves—where the most distinctive variations exist. To the naked eye the chief differences lie in length, cleanness, strength, and colour, while strength can be determined by those who are accustomed to handle the cotton. The apparent characteristics which determine the quality of cotton are :—

1. Length of the fibres.
2. Fineness.
3. Colour.
4. Cleanness.
5. Uniformity.
6. Strength.

7. Elasticity.
8. General appearance.

The microscopical characteristics are:—

1. Natural twist.
2. Thickness of the fibre walls.
3. Density.
4. Uniformity (or otherwise).
5. Hollowness.
6. Serrated Edges.

These varying characteristics are chiefly due to:—

1. The character of the seed.
2. The character of the soil.
3. The system of land preparation.
4. The methods of cultivation.
5. Atmospheric temperature and humidity.
6. The system of picking and ginning.

Character of the Seed.

Seed for sowing should be specially selected, athough in India and some other countries this important factor in successful cotton cultivation is neglected, or at least only carried out in a superficial sort of manner. Indifferent seed will not even under the most excellent systems of culture produce good cotton, and it is a well-known fact that the seed of successive crops rapidly deteriorate in quality.

Character of the Soil.

A light loamy soil is the best for cultivation. Dry, sandy, and moist clayey soils are the worst. Dry soils

produce irregular and weak fibres, while the plants themselves are stunted and unhealthy. Soils containing salt or saline matter in small proportion, whether situated in the vicinity of the sea, or inland, give the best results. This is shewn by the results of the cultivation of the Sea Island and some of the American cottons, and still further proved by the fact that the same seed in other soils with similar surrounding characteristics does not produce as good a crop if the saline constituent is absent. These facts will be dealt with more fully at a later stage of this work.

System of Land Preparation.

Land from which the fertilising properties have been removed by neglect, cannot yield a good crop. Manuring and ploughing are most essential agents, and yet in India and many other places they are considered of little importance. Ploughing in India consists of turning up only a few inches of the crust of the fields, and over this the seed is spread. It is not therefore surprising to find that year by year the crop instead of improving in quality remains stationary or deteriorates.

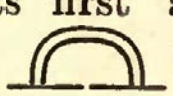
The plantation should be thoroughly ploughed and enriched by the use of natural or artificial fertilisers. The latter give less trouble, are more uniform but also more expensive.

The operation of sowing may be carried out in two ways—firstly in holes, and secondly in drills, as is the

plan now most generally adopted. Where the sowing is carried out in the latter system, the drills are made across the fields at a distance from one another of about five feet, (which is calculated to be sufficient space) to allow of the labourers, pickers and others passing between the rows without disturbing the plants. In the former way, holes are made in ridges raised at the same distance from one another as the drills—that is five feet—the seed holes being made by means of a pointed stick known as a "dibble"—and at about eighteen inches apart. Along the drills, or in each hole, as the case may be, the seed is plentifully scattered by women and girls, who carry it in their aprons, and sometimes in bags, while young persons of both sexes follow up behind with light hoes, covering the seed lightly over with soil.

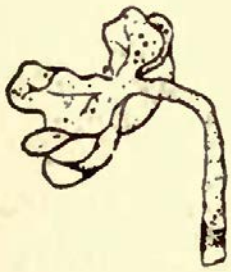
Methods of Cultivation.

The cotton plant in its earlier, and in fact throughout all the stages of its growth is extremely delicate and requires careful nursing, especially where it is likely to be attacked by frost or by insects.

When the sowing is finished, and before, and for some time after the crop makes its appearance, keeping the ground free from weeds is the main object to be looked to, otherwise the soil would become much impoverished, and the product would be of an inferior quality. In from five to ten days after sowing, the young shoots first appear above ground in the form of a hook  but in a few

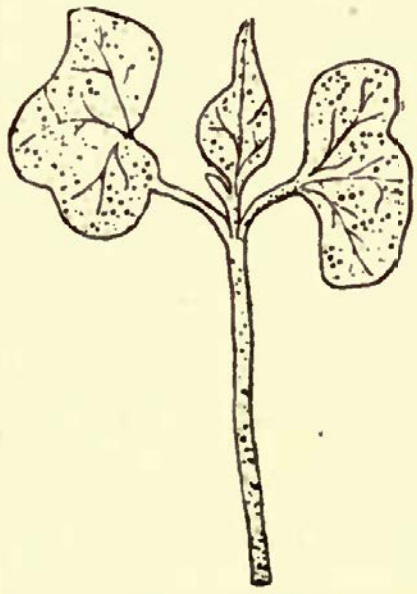
hours afterwards the seed end of the stalk or stem is raised out of the ground, disclosing two leaves folded over and closed together, as shewn at Fig. 2. The leaves and stems of these young plants are very smooth and oily looking, and of a fleshy colour and appearance, and, as before stated, extremely tender. In a short time after the plant has reached the stage shown in our illustration, it begins to straighten itself and deepen in colour, or rather, changes to a light oily green, while the two leaves gradually separate themselves until they attain the forms shown in Figs. 3 and 4. When this stage has been reached its development

Fig. 2.



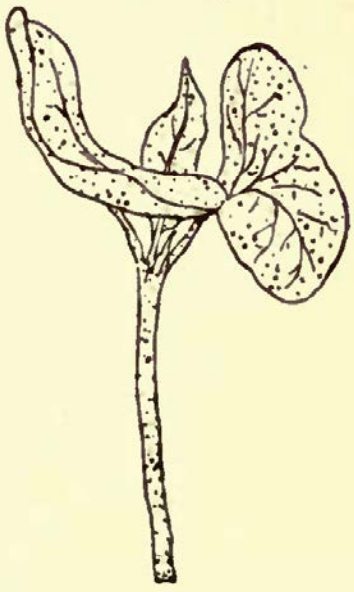
Cotton Plant in its second stage of growth.

Fig. 3.



Cotton Plant in its third stage of growth.

Fig. 4.



Cotton Plant in its third stage of growth.

is rapid, and proceeds in a similar form to ordinary shrubs until it reaches maturity.

8.—During the early development of the crop the plants are thinned out by the weak specimens being

removed. This allows space for the healthy plants to expand—a factor which is most important in all forms of agriculture.

The times of sowing depends to a certain extent upon atmospheric conditions, but the following is approximately correct.

March to April and May...	Egyptian, Texas.
April to May.....	Sea Island, Florida, Georgia, Mississippi, Louisiana, Alabama, Arkansas, Tennessee.
June to August.....	Indian (except Madras).
August to November.....	Madras cottons.
December to June.....	Brazil.

Atmospheric Temperature and Humidity.

Under this heading we are confronted with several points of much interest. Every one knows that in the cultivation of cotton a certain amount of moisture is necessary with a more or less tropical temperature.

Excessive heat causes the cotton to reach maturity too quickly, the bolls open before being fully developed, the fibre is short, irregular, and harsh.

Excessive rain not only retards the opening of the bolls, but prevents this necessary and natural operation being fully carried out. The fibres will not ripen properly, and will in all probability be stained and in a condition to encourage decomposition.

The erratic rainfall, the high temperature of the atmosphere, and the deficiency of humidity are the

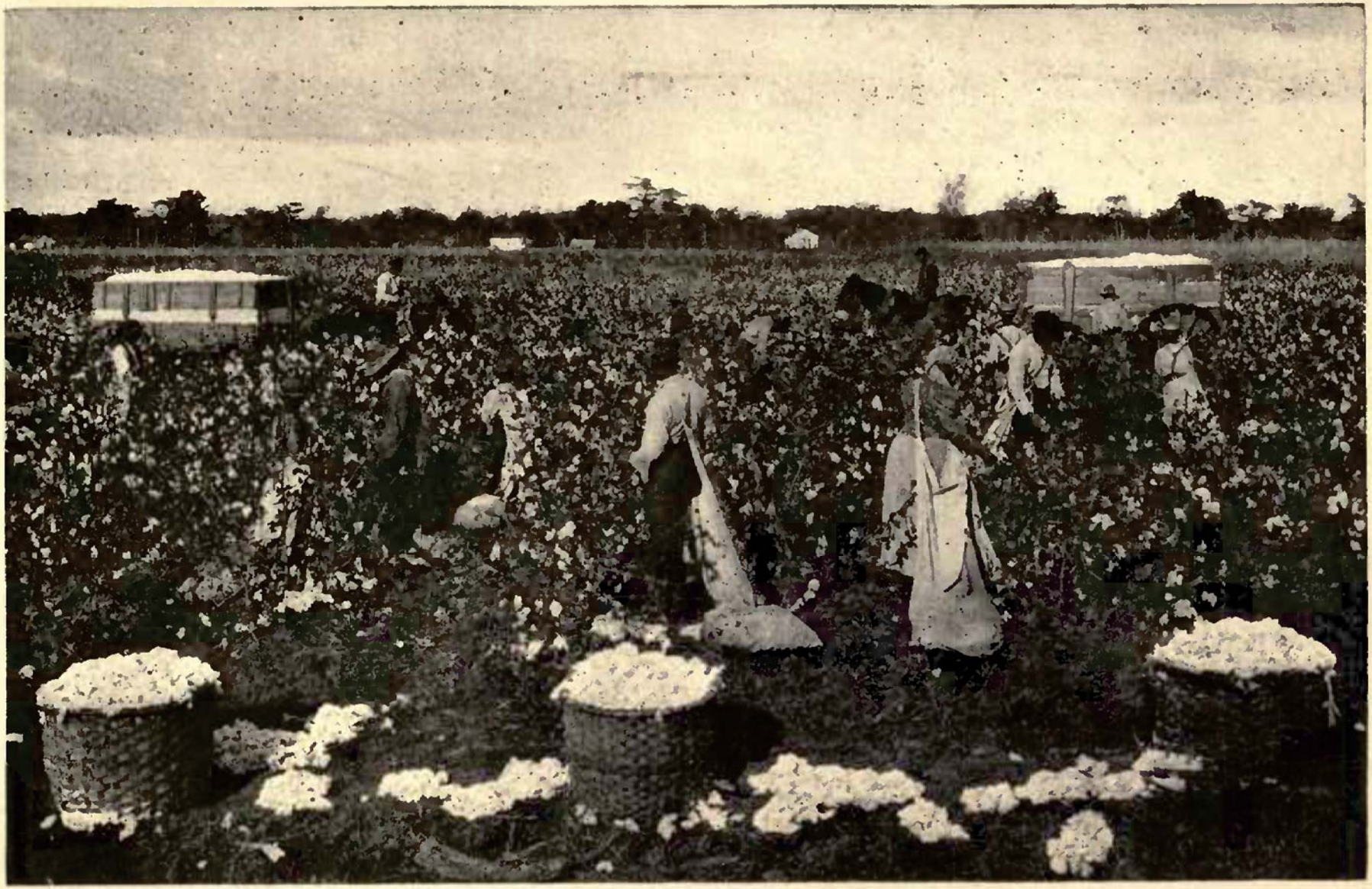


Fig. 5.—COTTON PICKING.

(From a Photograph by Coovert, Greenville, Miss.)

agents which will always stand in the way of any great improvement in Indian cotton. The systems of cultivation, the preparation of the fields, and the selection of the seed are all in the power of man, but the supernatural influences cannot be altered or compensated for to any great extent.

Systems of Picking and Ginning.

In these two somewhat simple operations, the cotton can to a considerable extent be made or marred. Unless the cotton is carefully picked large quantities of leaf and shell will be removed along with the fibre. The work is carried out by hand, the operators (with bags or aprons in front of them) moving from plant to plant and extracting the cotton from each mature boll. The leaf and shell in the cotton get broken up into minute particles and distributed throughout the cotton, thus injuring its appearance and increasing the percentage of loss which must be experienced in the mill.

Picking of the cotton from the boll should take place immediately maturity has been reached. If it is delayed too long, it collects sand and the heat of the sun dries and weakens the fibres. If it begins too soon the cotton will contain an excessive percentage of immature fibres, and thus increase the waste and difficulties of manipulation at the cleaning processes.

Ginning machines are of four distinct kinds, viz.:— single roller, double roller, knife roller, and saw gin. The saw gin is generally used on American cottons,

while the roller gins are chiefly used on Indian cottons. The knife roller is in favour for Egyptian and long fibred cottons, as the seeds are smooth and the fibres easily removed.

In all gins the chief objects aimed at, are:—

1.—To remove as much of the fibre as possible.

2.—To injure the fibre as little as possible.

3.—To prevent the breaking up, or the passage through, of the seeds along with the cotton.

The setting of the parts of the machine at which the cotton is stripped from the seeds is the all important matter. If too close the fibre may get broken, and if not close enough broken seeds will pass through along with the fibre.

The ginning machine owing to its tearing action on the fibres is a prolific *nep* producer, but this subject will be considered at another part of this book.

The quality characteristics of cotton already enumerated may be explained as follows:—

9.—*Length of the fibres.*—Not only do different varieties of cotton vary in length, but cotton from the same plantation and the same crop also vary. The minimum length of commercial cotton is about 5/8″ while the maximum is about 2″. A fair idea of the comparative lengths can be formed from the diagram Fig. 6, page 19.

Length in nearly every case is synonymous with fineness, and both characteristics are essential in the production of fine yarns of good quality. Short fibred cottons are useless for fine spinning because in the

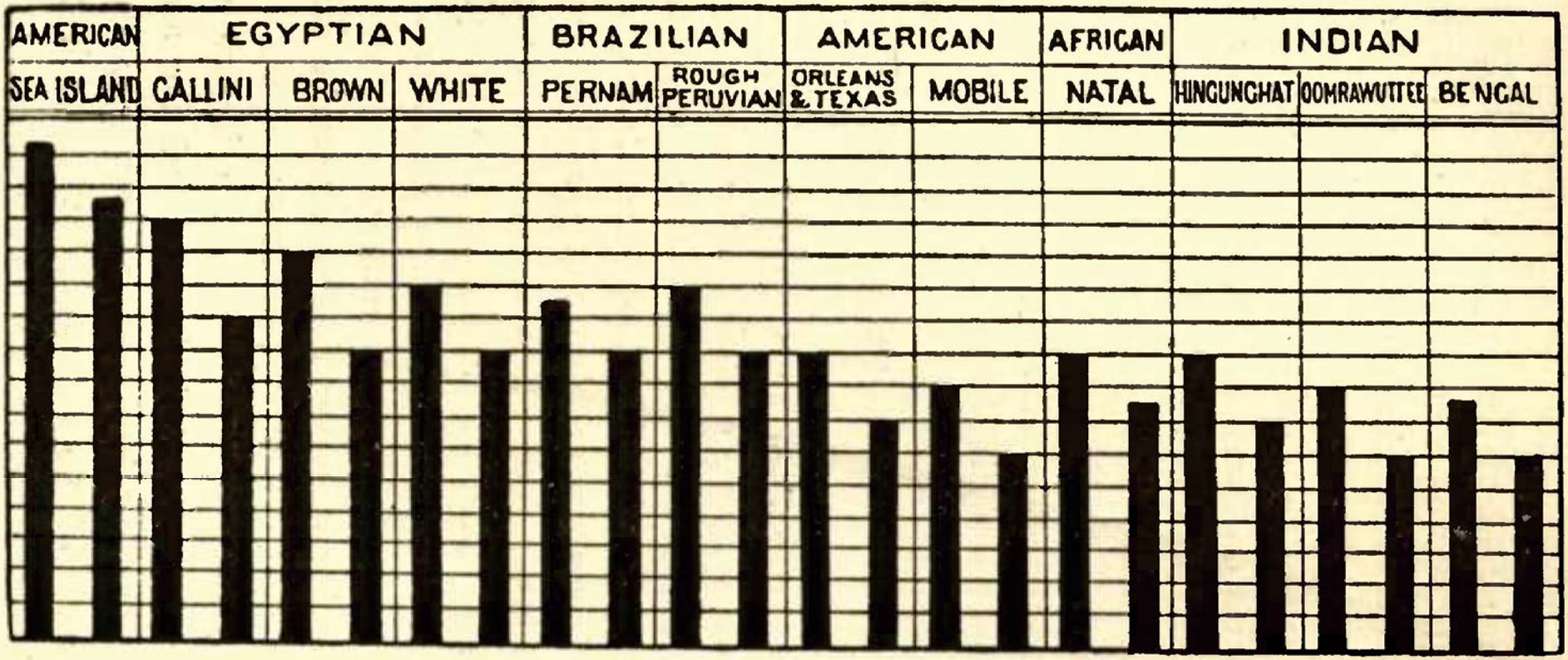


Fig. 6.—Diagram illustrating the maximum and minimum lengths of the fibres of the principal varieties of commercial cotton in comparison with one another.

twisting operation of the Ring Frame or Mule, the length of fibre would be incapable of receiving the number of twists necessary to produce strength.

Fineness.—Fineness is always a desirable quality. A fine fibre can be more easily and uniformly twisted than a coarse one, and a stronger and better looking thread can be obtained.

Colour.—Deliveries of any particular class of cotton should be uniform in colour, otherwise a shaded or streaky yarn will result.

The colours of different cottons vary from a dead white to a rich light golden tint, and for special classes of yarn the selection of cottons as to colour is important.

White cottons are as a general rule inferior in strength and spinning qualities to the other.

Cleanness.—Cleanness consists in the freedom of the stock from broken leaf, broken seed, sand and dirt. All these impurities are found in the best of cottons, but in the lower grades they are present in excessive quantities. Broken leaf is traceable to the picking, broken seed to the ginning, sand to natural or artificial causes, and dirt to careless handling.

Uniformity.—Under this heading can be included length, strength, colour, and cleanness.

Many cottons sold under certain known marks contain fraudulent admixtures of inferior material. This causes irregularity, and this irregularity will exist at every stage of the process right through to the yarn.

Irregularity in colour is also due to the same cause and has similar results. In all cottons however, there are natural irregularities which cannot be avoided. These may be due to varying systems of cultivation in the same district. No two crops even off the same field are alike, as the quality is affected by the atmospheric conditions which constantly vary.

Old cotton and new cotton also differ, the former being dryer, more brittle and weaker.

Strength.—Strength is an important factor, and as a rule, the coarser fibres individually are stronger than the longer ones. Collectively, as in yarn, the finer fibres make the stronger thread as a much larger number are incorporated. Strong cottons are useful for *warp* yarns, while soft cottons are chiefly used in the spinning of weft yarns.

Elasticity.—Dry, harsh fibres have little elasticity. The property of elasticity is necessary to enable the cotton to withstand the tearing and drawing actions to which it is subjected in the course of manufacture.

General appearance.—An experienced operator in cotton transactions can give a shrewd guess as to the quality of any particular supply immediately it comes in sight. The uniformity of colour, the absence of impurities, and the compactness of the fibres all speak for themselves to a certain extent.

The microscopical characteristics of the cotton fibre are peculiar, but they open the road to a clear understanding of their necessity in rendering the material of commercial value. The fibre is one long

flat cell or tube closed at the apex. It shows many convolutions (200 to 300) with the outer walls thicker than the centre. The density or opaqueness, the number of twists, and the thickness of the walls vary in different varieties. The serrated edges are formed by the natural convolutions, and these cause the fibres to interlock with one another, thus giving the yarn cohesion and strength.

No other commercial fibre possesses these characteristics. Long fibres such as flax, jute, etc. do not need them as their length compensates for the absence of the natural convolutions. The nearest approach to the cotton fibre is that of wool which has the serrated surface, but not the twist.

The importance of the softness combined with the natural twist can easily be arrived at in the following simple manner :—

If we take two samples of textile material, say one of cotton and one of flax, and after cutting the latter to an equal length with the former, we attempt to twist them into a strand or thread with our forefinger and thumb, it will be found on removing the pressure that the flax fibres have almost wholly uncoiled themselves, while the cotton retains almost exactly the same position into which it was twisted.

In wild cotton these characteristic features are, as a general rule, entirely absent; so that, therefore, being also comparatively (to other fibres of commerce) very short and weak, its fibres could not present sufficient surface to retain the twist imparted to them, and are

consequently worthless as far as manufacturing purposes are concerned. Another objection to wild cotton is that the fibres are all more or less solid, and possess little of the flexibility of the cultivated fibres.

The microscopical characteristics of cotton, wool, flax, mohair, and silk are shown in Figs. 7, 8, and 9.

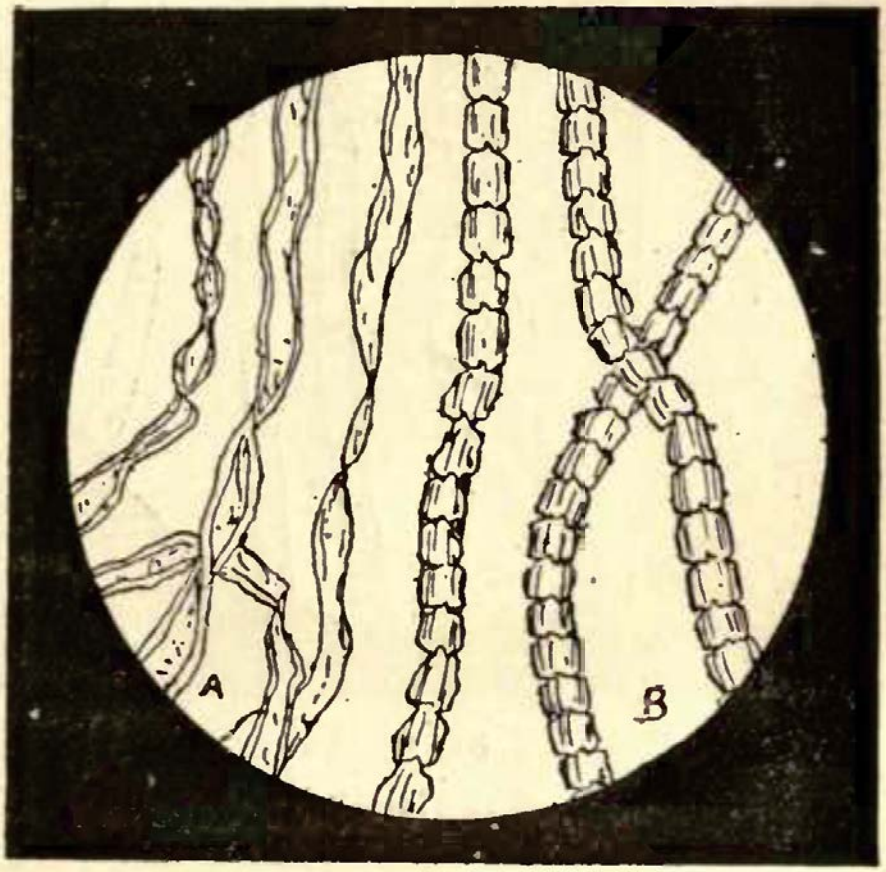


Fig. 7.

A Cotton. B Wool.

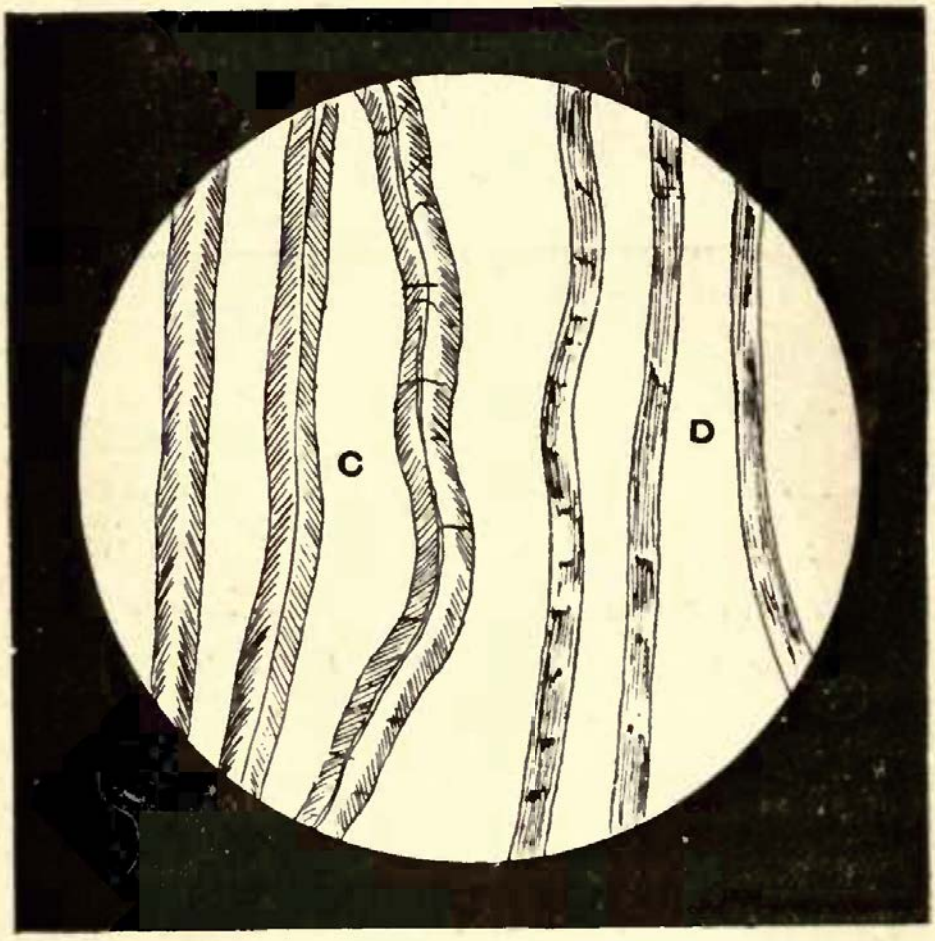


Fig. 8.
Flax Fibres.

Fig. 9.

E Mohair. F Silk.

Strength Tests of Cotton Fibres.

10.—Since the first edition of this book was written, I have made many tests of various varieties of cotton fibres, but the results have been so erratic even from different fibres from the same handful of cotton, that a fixed table of different averages would be misleading. The following are the most accurate results that I can arrive at:—

CLASS.	Breaking strength in grains—mean.
Sea Island	90 to 100
Florida Sea Island	90 to 110
Brown Egyptian	130 to 150
White	120 to 140
Pernambuco	120 to 140
Maranham	105 to 120
Orleans	130 to 140
Texas	130 to 145
Mobile...	110 to 120
Hingunghat	130 to 150
Broach	130 to 145
Dhollerah	110 to 130

It does not follow that the strongest fibres individually will collectively produce the strongest yarn. The thickness of the fibre, the number of its natural convolutions, and the length, are all agents which affect results in manufacture. For example, Sea Island cotton will make a stronger yarn than Hingunghat: This is owing to the fibres being smaller in diameter, consequently there is a larger number in every cross section of the thread, and these lie much closer together and in more intimate contact with one another. Unity is strength in animate or inanimate nature.

When we take into consideration the great delicacy of the cotton fibre, and the phenomena of its mechanical structure, it will be easy to understand that the utmost carefulness must be extended to it in

its application to technical purposes, if its essential characteristics and properties are to be retained in any proportion to their original and natural quality. Under ordinary circumstances of manufacture only slightly over 20 per cent of the strength can be utilised; and in cases where the material to be converted into yarn has been operated on by imperfectly worked machinery, or where the productive capacity of the various machines has been taxed beyond a proper limit, then only about 15 or 16 per cent of the fibre strength is left available for the constitution of the yarn. The following table gives the results of a number of experiments made to determine the strength of the cotton fibres after manufacture into yarn in relation to those in their natural condition:—

DESCRIPTION OF YARN.	Average No. of fibres in cross section of yarn.	Test strength of each fibre. Grains.	Calculated strength of yarn. lbs.	Actual strength of yarn. lbs.	Percentage of strength utilised.
32's twist, American Cotton ...	120	140	200	49·5	24·7
36's " " " ...	110	140	176	40·0	22 7
40's " " " ...	100	140	160	36·0	22·5
46's " Egyptian Cotton ...	132	146	220	52 0	23 6
50's " " " ...	110	146	184	46·0	25 0
60's " " " ...	100	146	167	33·5	20·6
70's " Brown " " ...	74	150	127	27·5	21·6
80's " " " " ...	60	150	103	23 5	22·8

From this statement it will be observed that the average percentage of the strength of the fibre which enters into the composition of the yarn is, in American cotton, 23·3; White Egyptian, 23·06; and Brown

Egyptian, 22·2. All three, therefore, are much alike.

From additional experiments which I have made in the same direction I find that in combed yarns the proportion of strength is greater than in those which have only been carded. The cause of this is not far to seek. In the former all fibres which fall short of a certain length are removed as waste, while the remainder, which are retained for the manufacture of the yarn, are all approximately of equal length, so that the yarn produced from them is much more even, the fibres better distributed, and the average tensile strength increased. In cotton which has only been carded, the length of the fibres is more irregular and the stage of their maturity varies, consequently only partially ripe fibres may enter into the yarn, and these, although being comparatively weak and soft, have nevertheless the weight necessary to increase the hank without imparting a corresponding addition to the strength. The following is the result of the experiments to which I have referred :—

DESCRIPTION OF YARN.	Average No. of fibres in cross section of yarn.	Test strength of each fibre. Grains.	Calculated strength of yarn. lbs.	Actual strength of yarn. lbs.	Percentage of strength utilised.
80's twist, Gallini Cotton ...	90	120	100	25	20 3
120's „ „ „ ...	55	120	66	18	24 2
120's „ „ „ ...	50	120	68	15	22
143's „ „ „ ...	40	120	55	13	23 6
165's „ Sea Island Cotton...	45	100	55	13	25·4
190's „ „ „ ...	38	100	43	10·5	24·4

CHAPTER II.

General Characteristics of the Crops of different Countries and particulars relating to their Cultivation.

American.

11.—The typical American cottons, that is those of the Gossypium Hirsutum species, although only of a fourth rate quality, nevertheless, from their importance and the enormous extent of their cultivation, demand consideration first under this heading. In no other country in the world is the cultivation of the cotton plant so important a factor in its commercial associations, or gives employment to such a large percentage of the population as in the United States. The soil and climate being favourable, and the people naturally enterprising and persevering, agriculture in this form is conducted on the most systematic lines, and in fact has been raised from being a mere scheme for profitable employment to a scientific industrial pursuit. From this cause, therefore, the cotton crop of America is much superior to that of our next source of

supply—India, that is as regards freedom from impure matter, and the manner in which it is prepared for market. The plantations also are on a larger scale than elsewhere, so that each season's crops are raised under more equitable conditions of growth, and the qualities of the cotton are not so liable to variation. The Sea Island cottons were first cultivated in America at the close of the last century, in the belt of islands lying alongside the coast of Georgia, North Carolina and Florida, and from which they obtained their name. The soft, maritime climate, peculiar to these islands and to the shores of Florida and Georgia, being well adapted to the cultivation of cotton, the development of the plant has there attained to its highest standard of excellence, while its fibrous product is unequalled in length, strength, fineness or appearance by that of any other district in the world. Between the commercial standard of Sea Island cottons, and those raised in the other States, there is a very wide difference, the latter being much shorter. Although inferior, however, in this respect, the Gossypium Hirsutum species of cotton is nevertheless the most valuable to mankind at large, as its product is specially suited for the manufacture of those yarns of which by far the larger quantity is required, that is, yarns ranging from 30 up to 60 hanks to the pound. The area each year placed under the cotton crop in the United States ranges from 26,000,000 to 29,000,000 acres, an average year being as follows:—

STATES.	Acres planted	Yield per acre.	Average yield per acre	No. of Bales.
Texas	7,748.000	226 to 185	200	2,438,565
Georgia	3.870.000	183 to 172	175	1,345,699
Alabama	3,362.000	195 to 151	170	1,005,313
Mississippi	3,124,000	229 to 159	190	1,203,739
South Carolina ...	2,533,000	245 to 167	200	830,714
Arkansas	2,089,000	290 to 223	250	669,385
North Carolina ...	1,476,000	227 to 199	210	503,825
Louisiana	1,401,000	272 to 234	250	669,476
Tennessee	913,000	181 to 170	175	192,263
Indian Territory ...	413,000	325 to 289	300	119,939
Oklahoma	308,000	249 to 318	280	66,555
Florida	186,000	117 to 133	125	41,855
Missouri...	59,000	206 to 275	240	12,275
Virginia, etc.... ...	52,000	144 to 180	160	8,245

To a certain extent the variation in yield per acre of different States can be readily understood, but in some respects it seems excessive. For example, the cotton grown in Indian territory is returned at 300lbs. per acre, while Florida is given at 125lbs. In the States producing over one million bales the variation ranges from 170lbs. to 200lbs. per acre, Texas giving a yield of 20 per cent more than Alabama.

The total crop varies from 10,000,000 to 12,000,000 bales of 510·24lbs. each, the crop for 1902-03 being 11,415,000.

The transactions in American cotton are chiefly carried out at New Orleans, Galveston, and Savannah, but Norfolk, Wilmington, Boston, New York,

Fig. 10.
Chief Cotton States.

Charleston, Pensada, and Mobile have also fairly large interest, particularly the two first named.

The new cotton is generally received at the following ports about the dates given :—

Galveston	July 12th.
New Orleans	July 12th.
Savannah	August 3rd.
Mobile	August 8th.

Augusta ... ... August 12th.
Charleston... ... ... August 12th.

Cotton picking generally closes:—

Florida ... ... November 20th to 24th.
Other States ... ... December 2nd to 12th.

For American cotton, Liverpool is the largest receiver, Bremen (and Emden) stands next, then Havre, Manchester, Genoa, Barcelona, and Hamburg. If we take the import of American cotton by Hamburg to be represented by 1, then the others will be represented as follows:—

Barcelona	1·15
Genoa...	1·6
Manchester	1·86
Havre...	3·3
Bremen (Emden)	6·8
Liverpool	11·6

Egyptian.

12.—In Egypt, at the present time, four different species of the cotton plant are largely cultivated: 1, Gossypium Barbadense (Gallini); 2, Gossypium Herbaceum (Brown); 3, Gossypium Hirsutum, and 4, Gossypium Peruvianum (both white). Nos. 1, 3, and 4 are exotics, while No. 2 is the native plant of the country. The Egyptian cottons are noted for their golden colour, which is of a different deepness of tint in the product of the various species, the white being less distinct than the Gallini, and the Gallini less than the native variety. The fibres are generally very strong

and fine, consequently they are well adapted for the manufacture of either twist or weft yarns. As the plants, however, are largely dependent for moisture on the waters of the Nile, it will be easy to understand that when this river fails to rise to its customary height the crop of that season will differ in many respects from one in which the overflow has reached the maximum level. On the seeds of all the Egyptian plants there is always to be found an undergrowth of short hair, or undeveloped fibre, which varies in quantity in different seasons, and is to a certain extent, traceable to the mutation of the irrigatory system.

A noteworthy feature in connection with the cultivation of Egyptian cottons is, that in the plantations situated within the country drained by the Nile, manures and fertilisers are not required, for when the water of that river subsides after each annual overflow it leaves behind a rich deposit of mud better adapted to germination and the development of the plant than any artificial matter which could be introduced. Taken as a whole, Egypt produces the best class of cotton of any other country in the world, and were it not for the short fluffy fibre which grows so largely on the base of the seed, and gets removed with the good cotton when passing through the ginning machine, they would also be the easiest to work into yarn.

The presence of the endochrome in the fibre walls of the Egyptian cottons, which imparts to them the golden colour that they possess, renders them less suitable for mixing with the great bulk of the product

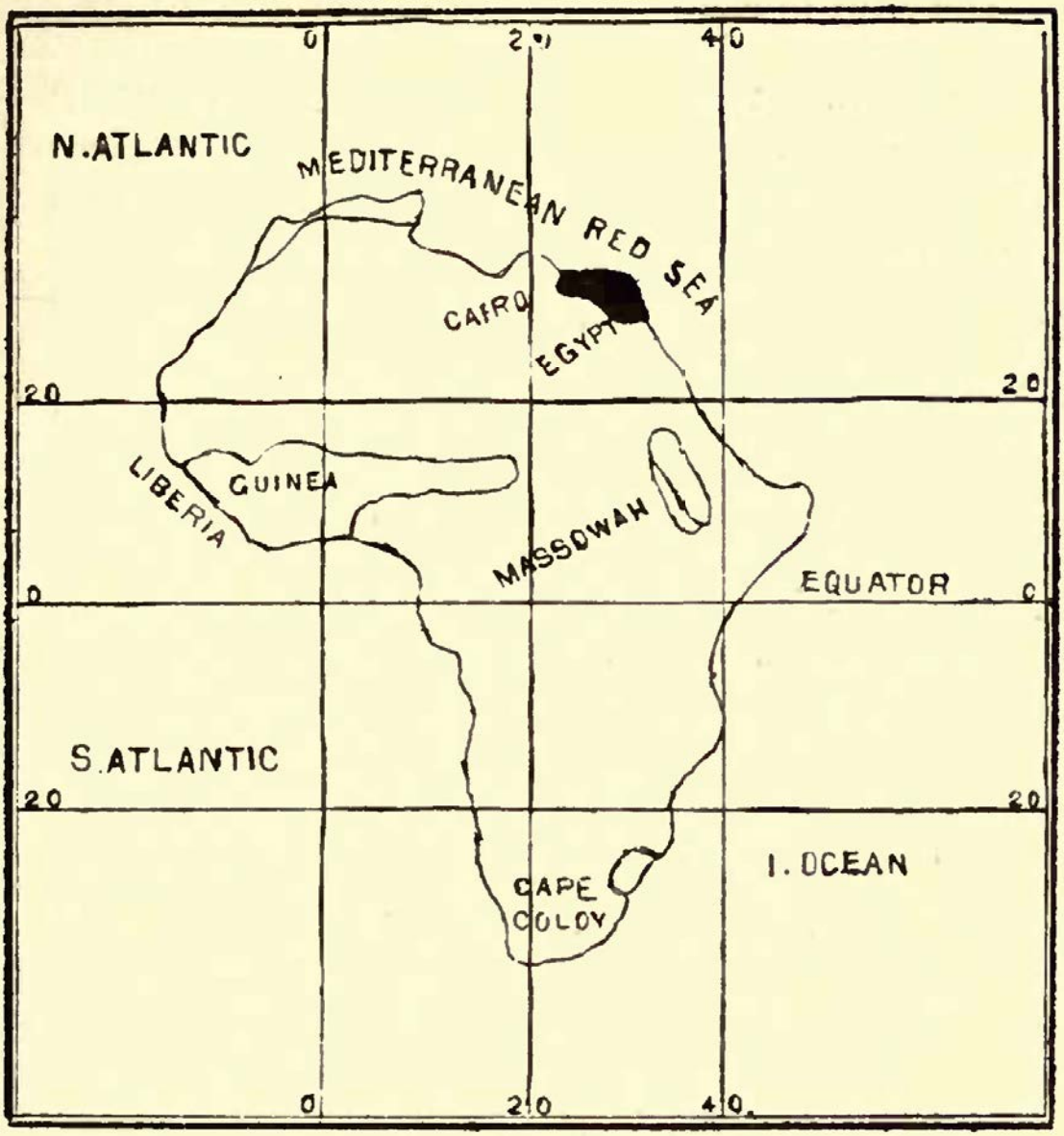


Fig. 11.

Cotton growing districts of Africa. (Black portions show chief districts). Enclosed portions (not black) show minor growing districts.

of other countries. By this characteristic alone, yarns spun from Egyptian cottons are easily distinguishable in a raw, and even after having been subjected to a bleaching process.

At the present time the total annual crop of Egyptian plantations amounts to 850,000 to 875,000 bales, the average under cultivation for season 1903-4 being estimated at 1,800,000.

The crop, in round figures, is exported as follows:—

Liverpool	268,000
Manchester	148,000
Boston, &c.	56,000
New York, Philadelphia, &c.	17,000
Odessa and Baltic Russia	73,740
Greece, Turkey, &c.	970
Trieste and Fiume	77,500
Venice	16,000
Naples	3,700
Genoa and Leghorn	45,500
Marseille	38,800
Barcelona	22,200
Havre and Dunkirk	45 200
Antwerp and Ghent	22,600
Hamburg and Bremen	20,000
Bombay, &c.	9,400
Japan	8,600

It is interesting to note that special recommendations through Lord Cromer have been urged for the cultivation of cotton in the Soudan, and the enlargement of the area generally in Egypt, and that an Association has been formed with the object of encouraging and developing the growth of Cotton in Egypt and in British colonies.

E. Indian (Surat).

13.—Prior to the American Civil War little cotton of this class was imported into Great Britain, almost the entire growth having been used in the native

domestic manufactures. When, however, from that cause our American supplies ceased, and the ever-memorable cotton famine began, attention was directed towards India as a probable source of supply, with the result that in a few years' time the cultivation of the cotton plant was raised from comparative insignificance to that of secondary importance.

Between the finest and the poorest classes of the Indian cottons, there is a very considerable difference; the length, fineness, regularity, and strength of the fibres individually, and their freedom from impurities in the bulk, being much superior in that known as Hingunghat to the Bengal or Sind cottons. Taken as a whole, the Indian cottons are also, as regards their general quality, excepting, perhaps, length of fibre, inferior to any other commercial variety. This is in a great measure caused by the negligence and carelessness displayed in collecting the crops, and in separating the seed from the cotton during the operation of ginning. There are, doubtless, natural defects, such as irregularity in the twist, diameter, and ripeness of the fibre; but the effect of these would not be felt so much if the artificial damage done to the structure, and bulk of the material was not so great. From these causes the Indian (Surat) cottons are relatively wasteful to work into yarn, for it is of course absolutely necessary that the seed, leaf, sand, and other impurities which they contain, be got rid of before a satisfactory product can be obtained from them. From the same causes also they are only adapted to spin the lowest numbers of

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yarn, and could not by any possibility, with existing machinery, be reduced to a finer thread than about 40 hanks to the pound. Under these circumstances, therefore, it is difficult to understand how the Hindoo weavers could spin the yarn and weave the delicate gauze-like muslins which the East India Company imported into this country. Dacca was long famed

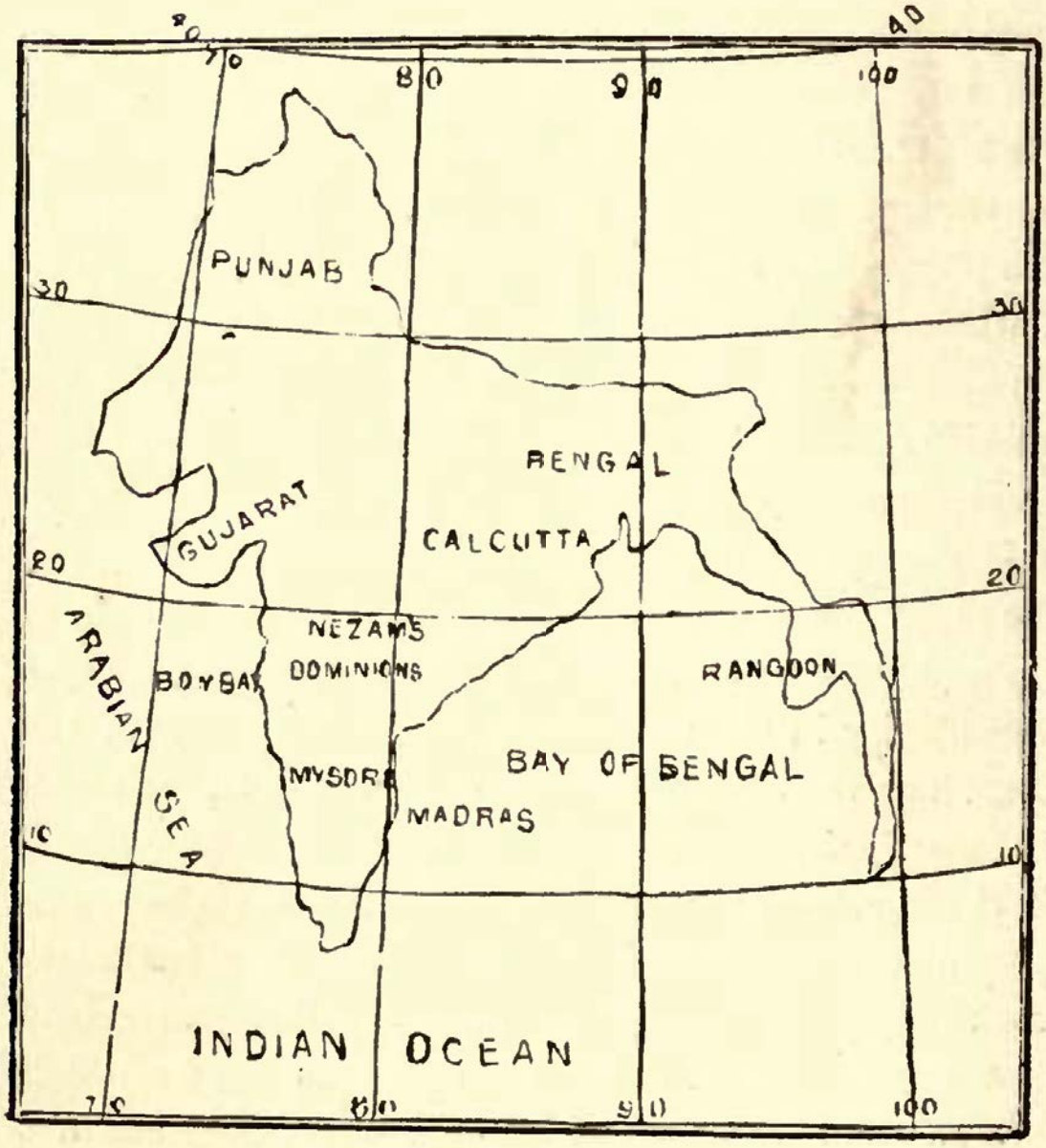

Fig. 12.

[All India cultivates cotton largely, and particularly in the districts named.

for the manufacture of this class of fabric, although the cotton raised in the district was much inferior in every respect to that grown in the Berar Province at the present time. Of the extraordinary fineness of these muslins some wonderful tales are told, many of which are probably exaggerated; but it is a well known fact that some of those which the East India Company retained in their museum, were composed of yarns so fine, that we, with all our advancement in manufacturing appliances, and using the silky long fibred Sea Island cotton, could scarcely equal, and certainly not surpass.

At the present time the quantity of cotton raised in India ranks next to the production of American plantations, but the proportion consumed in Great Britain is much smaller.

The present production is about 3,000,000 bales of 400 lbs. each, obtained from 16 to 16¼ million acres distributed as follows:—

Presidency or Province.	1903.	1902.	1901.	1900.	1899.
Bombay and Scinde	4,430	4,524	4,325	3,187	5,190
Punjaub	1,194	1,027	1,215	988	789
Provinces of Agra and Oudh	1,282	1,154	1,265	1,213	1,152
Bengal	114	119	128	161	168
Rajputana	457	282	369	325	479
Central India	586	529	543	480	471
Berars	2,766	2,689	2,522	1,984	2,476
Central Provinces	1,152	980	1,004	713	668
Hyderabad (Nizam's)	2,514	2,374	2,544	1,932	2,603
Madras	1,777	1,546	1,578	1,583	1,517
Mysore	55	45	55	40	} 262
Assam	40	40	35	35	
Burmah	134	131	142	149	
Ajmere and Meywara	45	35	39	35	38
Total	16,546	15,475	15,764	12,825	15,813

14.—The chief ports of exportation are :—

Bombay ...	75% of total.	Calcutta ...	5% of total
Kurrachee.	10·6% „	Madras ...	3% „
Tuticorin...	6% „	Coconada...	·4% „

The yield of some of the chief varieties of Indian cottons for the past three years, omitting 000's, were :—

ESTIMATED YIELD OF COTTON OF THE VARIOUS SECTIONS OF INDIA.

For Years ending June 30, as reported by Messrs. Lyon & Co., of Bombay.

(In Thousands of Bales of 400lbs.)

Presidency or Province.	1903.	1902.	1901.	1900.	1899.	1898.	Normal Yield.
Bombay and Scinde	869	580	709	97	1,135	868	1,054
Punjaub	229	213	205	139	167	224	162
Provinces of Agra and Oudh	334	369	215	160	190	169	179
Bengal.....	20	20	26	23	26	30	52
Rajputana.....	164	88	101	44	118	138	170
Central India	295	217	192	69	239	183	85
Berars.....	275	245	245	21	178	186	196
Central Provinces..	203	152	184	63	123	119	78
Hyderabad (Nizam's)	330	337	332	74	326	298	463
Madras	301	265	258	206	265	269	277
Mysore	9	7	8	3	} 52	8	10
Assam...	10	10	9	8		10	10
Burmah—Upper and Lower	21	13	21	33		23	25
Ajmere and Meywara	10	9	9	4	9	10	11
Corrected total	3,070	2,525	2,517	944	2,827	2,534	2,772

Order of Arrival of Cotton into Bombay.

Bengals.	Broach.
Khandeish and Berars.	Dholleras.
Hinghunghat.	Comptas and Dharwars.
Barsi and Nuggars.	Westerns and Madras.

Tinnevelly.

GROWTHS.

The following are the principal descriptions produced in India, the commercial names by which they are known, the districts and provinces where grown, and the ports from which they are shipped :—

Varieties.	Principal Districts.	Provinces.	Shipped at
Hinghunghat...	Wurdha, Nagpore, Nimar, &c.	Central Prov'ces	Bombay.
Broach	Broach, Baroda, Surat, &c.	Bombay	Do.
Dhollera ... Bhownugger	Kathiawar, Ahmedabad, Baroda, Cutch, &c.	Do.	Do.
Oomrawattee	Khandeish and Nasick	Do.	Do.
	Ahmednugger	Do.	Do.
	Akola, Amraoti, Buldana, &c.	Berar	Do.
Coompta	Bijapore, Dharwar, Belgaum, &c.	Bombay	Do.
Dharwar	Dharwar and Southern Mahratta States ...	Do.	Do.
Sind	Hyderabad, Shikarpore, &c.	Sind	Kurrachee.
Bengals ...	Delhi, Umballa, Umritsur, Mooltan, &c. ...	Punjab	Bombay, Calcutta and Kurrachee.
	Meerut, Agra, Allahabad, Rohilkund, &c. ...	N.-W. Provinces	
	Sitapore, Lucknow, &c	Oudh...	
	Jeypore, Meywar, Bhurtpore, Ulwar, &c. ...	Rajputana ...	Bombay.
	Gwalior, Indore, Bundelkund, &c	Central India ...	Do.
Westerns...	Sholapore	Bombay	Do.
	Bellary, Anantapore, Cuddapah	Madras	Bombay and Madras.
	... ...	Nizam's territory ...	Do.
Salems (or Coimbatore)	Coimbatore, Salem	Madras	Madras.
Coconada ...	Kistna, Nellore, Godavery	Do.	Coconada and Madras.
Tinnevelly ...	Tinnevelly, Madura, Trichinopoly	Do.	Tuticorin.

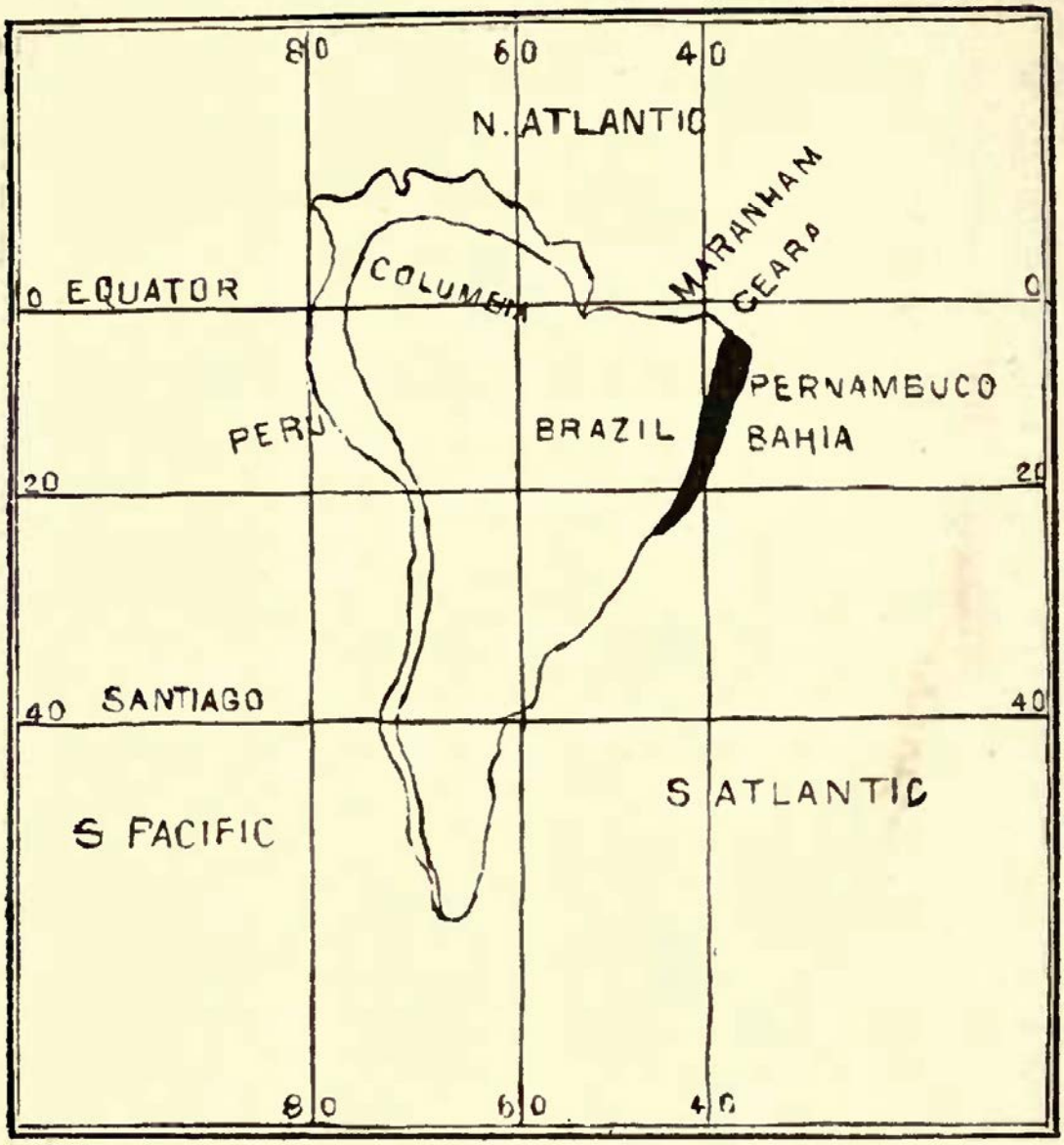

Fig. 13.

Cotton growing districts of South America (black portion shows chief districts). Enclosed portions (not black) show minor districts.

Brazilian and Peruvian.

15.—In the various countries and districts situated in Central and South America the cotton plant is cultivated to a considerable extent, the product of which, in quality, takes third place in our markets. These cottons, with two exceptions, are raised from the native arborescent species—Gossypium Peruvianum, which, unlike that of other countries, is a perennial

plant, bearing crops for several years in succession, although it is only those of the second and third year's growth which are utilised. These exceptions which we have spoken of are known (1) as Peruvian Sea Island—Gossypium Barbadense, and (2) as Santos; the latter being raised from the American species—Gossypium Hirsutum, lately introduced into Brazil, and cultivated to some little extent along the South Eastern coast. Although retaining many of the characteristics of the American cotton, yet it has also largely partaken of the peculiarities of the Brazil varieties, being harsh and coarse. As no advantages have been gained by its introduction, it is very doubtful whether its cultivation will ever be developed to any considerable extent. In Peru, the most prolific district is in the vicinity of the high table lands, as the climate is milder and of a more regular temperature, in fact, has been fitly described as a "perpetual spring." On the coast the climate is too hot and moisture deficient, as rain seldom or never falls. In Brazil a large portion of the country is adapted for successful cotton cultivation, the climate being mild and the soil fertile, but, unfortunately, only a very small proportion of the surface is so utilised, much valuable ground being entirely unoccupied. The plantations too, which do exist, are generally not kept up to modern ideas; the cultivation of the plants and picking and ginning of the crops being often inefficiently performed, whereby the value of the crops are reduced. The plantations are generally small, so that

this, no doubt, accounts for the irregularity of the crops from even the same district, as the methods of cultivation and the seed vary slightly under different planters. All Brazil and Peruvian cottons are characterised by a dryness, harshness, and roughness in their structure, which are not so apparent in any other commercial cotton. The fibres are generally long and strong, and therefore better adapted to enter into the composition of twist yarns. The smoother varieties incorporate fairly well with either Egyptian or American cottons, when a well arranged mixing of the different varieties is made. Several years ago, the cottons of this class were imported into this country in a very dirty state; but each year they have improved considerably in this respect, and can now bear comparison with the product of other districts. Yarns spun from Brazil cottons have also a harsh and somewhat brittle structure in comparison, say, to either American or Egyptian, but they form a convenient connecting link in price and quality between these two varieties.

The chief export ports and the quantity of fibre exported in bales of two-and-a-half cwts. fluctuate considerably, but average about :—

Pernambuco	173,000
Ceara, &c.	50,000
Paraiba, &c.	50,000
Rio Grande, &c	44,000
Maceio...	30,000
Maranham	2.000

African.—In the detailed descriptions of the different commercial varieties of cotton we have dealt at considerable length with the product of this continent, so that there is little more to add to the explanation there given, and to which the reader should refer.

The Secretary to the British Central Africa Chamber of Agriculture and Commerce has recently reported that all the conditions favourable to the growing of cotton on a large scale exist in Central Africa. The plains on the Zambesi and Shiré rivers are admirably adapted for the cultivation of the cotton plant, and in the Shiré highlands there are numerous valleys which contain the rich black "cotton" soil so much sought after in India. Everything was in favour of the growing of cotton as regards land and labour, and the only question would seem to be the one of freight.

China.

In China the cotton plant is cultivated to a very considerable extent, but the product is used almost entirely in the native manufactures. During the cotton famine, however, and at different intervals since, small portions have been imported into this country which were short and rather weak in the staple, and of a white, clean colour.

Many parts of China, both as regards soil and climate, could easily be adapted for the successful cultivation of the cotton plant, and energetic efforts have of late been made in this direction. In the

Yangtze-Kiang the soil is fertile, and abundant crops are produced, and although reliable data is not obtainable the best informed sources record a minimum production of cotton fibre of 1,300,000 bales of 500lbs. each. Added to the cotton imported, China consumes about two-and-a-quarter million bales, and only exports about one-tenth of its own production.

Russia.

A few years ago it would have been considered absurd to imagine that any of the districts under Russian rule could have become even a minor factor in the cultivation of cotton. The fallacy has been dispelled, as at the present time in Bokhara alone the crop has now reached 600,000 bales, and is rapidly increasing.

In other parts of the world the cotton fibre is grown to some extent for commercial purposes. In Syria the cotton plant is cultivated, the yield being from 26,000,000lbs. to 30,000,000lbs. Cyprus, Queensland, Polynesian Islands, Italy, Sicily, Turkey, Greece, all contribute (however small) to the supply of raw material.

It is natural to suppose that cottons obtained from such varied and widely separated districts differ in almost every respect, and the importance of selection to obtain the best results in manufacture is apparent. As a general rule, however, fineness or smallness in diameter is associated with length and spinning qualities.

CHAPTER III.

16.—The cotton which possesses the longest has also the finest filament, and in general possessed of the natural twist in a more perfect and highly developed form. From these characteristics alone it is, therefore, capable of producing a yarn of great strength in comparison with others, the chief peculiarities of which are shortness, coarseness and fewer convolutions, irrespective of other qualities of which it may be possessed. In all good commercial fibres of cotton there is necessarily (1) a very small percentage of solidified oil distributed over the internal surface of the fibre, and deposited when the vital fluids were in active circulation, and (2) a certain percentage of moisture, known as water of hydration. These, together, impart to the fibres the softness, suppleness, elasticity, and in a great measure the tenacity, without which they would be almost useless for manufacturing purposes, as a cotton which may have been exposed, say, for example, to the atmosphere in a warm room for a considerable time, becomes dry, brittle, and, consequently weak, owing to the evaporation of the moisture and to the liquefaction and absorption of this succulent matter. The quantity of water, however, contained in any cotton should be very small, never, in fact, exceeding about 5 per cent,

otherwise it may be safely assumed that when the percentage exceeds this limit, that the water has been artificially added with the fraudulent intention of increasing the weight. Of late years systematic damping of the bales has been carried out before reaching the purchaser, and large deliveries of cotton at several of our spinning concerns have been found to contain from 8 to 10 per cent of moisture when taken from the bale and exposed in a loose condition to the ordinary atmosphere of the spinning rooms; and in one bale opened some time ago at a Lancashire mill, it was found that the quantity of water contained in it amounted to 23 per cent. All cottons admit of the rapid evaporation of their moisture, and are also equally as good and rapid absorbents; consequently, the weight of any given quantity will vary in accordance with the temperature of the surrounding atmosphere—in wet and damp weather the weight being considerably greater than when the air is dry and warm. To arrive at as accurate a decision on the point as possible, several tests were made with 5lb. samples of cotton, with the following result. During the first few days, the weather being wet and damp they were weighed at intervals, and the maximum weight was found to be as follows—

SAMPLE.	WEIGHT.
No. 1	5·20 lb.
No. 2	5·00 lb.
No. 3	5·16 lb.
No. 4	5·12 lb.

equal to an average of 5·12 lb. When warm and dry weather succeeded, the weight gradually decreased until the minimum had been reached, as follows :—

SAMPLE.	WEIGHT.
No. 1	4·90 lb.
No. 2	4·76 lb.
No. 3	4·80 lb.
No. 4	5·14 lb.

or equal to an average of 4·90 lb., thus showing a loss and extreme variation of 4·3 per cent. After obtaining this result, the samples of cotton were placed in one of the spinning rooms, exposed to the heated atmosphere of the rooms, when in a few days they shewed a further average loss of 1·3 per cent., making a total of 6·2. This quantity is, of course, above the average, but the moisture was not artificially added. The samples were, however, taken from a new crop, which always contains a greater percentage of water than cotton a season or even a few months old. With the yarn in the cop similar tests were made, and with the same result, only to a lesser extent, as will be observed from the following statement :—

SAMPLE.	MAX. WEIGHT. dwts. grs.	MIN. WEIGHT. dwts. grs.	LOSS.
No. 1 ...	24 23 ...	24 6 ...	2·84 %
No. 2 ...	26 4 ...	25 10 ...	2·86 %
No. 3 ...	25 0 ...	24 7 ...	2·83 %

The average loss on the yarn was, therefore, 2·84 per cent. To test, also, the actual effect on the spinning properties of the cotton after extracting the moisture

as effectively as possible from the walls of the fibres, six bobbins were taken from a roving frame—the weight, or, in technical terms, the hank of any given length, being alike in all of them—placed three in a stove where the temperature varied only from about 49° F. to 50° F., and the other three in a warm room with an average temperature of 120° F. At the expiry of about seventy-two hours, on removing them from their respective positions and placing them in the creel of the mule, it was found that it was only with the greatest difficulty that the threads produced from the latter could be kept up. The whole appearance of the yarn was parched and brittle, and felt rough to the touch, so that when the carriage began to recede from the beam, and the strain or drag to be exerted upon the thread, it snapped suddenly, almost as if it had been cut with a sharp knife. After the bobbins, however, had been in the creels for some time, and had begun to absorb the moisture from the surrounding atmosphere, an improvement in the spinning set in and continued, until in a few hours little difference could be detected from the others. Another cause which renders an excessively dry fibre unfit for spinning properly is, that cotton without moisture is a good conductor of electricity, so that by the friction of the drawing rollers it has a tendency to lap instead of passing on to the point of the spindle. In the working of the three bobbins removed from the stove nothing particular was observable, excepting that they seemed to spin exceedingly well; but on weighing a

wrapping of the yarn spun from the two sets, considerable difference was found in the hank, that produced from the dried bobbins showing up on the index as 104's, and the other 100's, or a difference of four hanks. All practical spinners have experienced the effect that the weather produces on the spinning of cotton yarns, for when the air is very dry, and continues so for several days, the yarn on the mules will show a much greater percentage of breakages in the stretch than when it is moist and humid.

17.—In spinning all yarns, but more especially the finer varieties, it is essential that a high temperature be maintained in the mule rooms, otherwise the process could not be conducted in a very satisfactory manner. This fact everyone in connection with a cotton mill is thoroughly acquainted with. We have already stated that on the internal surface of the fibre there exists an oleaginous deposit. This oily matter when exposed to a cold atmosphere becomes partially solidified, and viscidity therefore increases, so that it has a tendency to stick or adhere to whatever it comes in contact with. To reduce its viscous properties by means of the liquefaction of this oily substance is therefore the most important reason why a high temperature is necessary in yarn spinning.

Mature, Half Ripe, Immature Fibres.

Throughout all our cotton supplies three classes of fibres are distributed to a greater or lesser extent, viz.:

(1) Unripe, (2) half-ripe, and (3) ripe. This may arise from a variety of causes, the principal being, firstly, owing to the wool being removed from the pod before being thoroughly exposed to the maturing influence of the sun's rays, and secondly, to the fact that the stages of maturity to which each filament may have attained varies considerably even on different parts of the same seed. The explanation of this latter point has been traced to several theoretic and also recognised characteristics of growth, viz.: (1) That the germination of cells does not begin simultaneously at every point on the surface of the seed; (2) that the absorption of the parts of the cell walls in contact throughout each linear deposit is not effected at the same moment; and (3) that the secretive and suctorial powers of each individual tube are not all of the same force and energy. Fibres produced on the crown of the seed are in every way more advanced and developed than those on the base; and it is by the removal of this undergrowth, in the process of "ginning," that so much immature fibre exists in our supplies. Unripe cotton, when examined by the aid of the microscope, appears extremely thin and transparent, and generally with little or no twist, so that, like the wild cotton, it is therefore of little use for manufacture. When it exists to any great exent in any of our supplies, it seriously reduces the value of the material as being in what I might term a green state; it contracts and curls up when subjected to the warm atmosphere of the factory rooms, and by entwin-

ing itself round the good fibre it becomes exceedingly difficult to remove, and often shows up as white specks in the after processes of manipulation. Cloth produced from a yarn, the cottons used in the composition of which contained any considerable quantity of unripe fibre, is greatly deteriorated in value, as the little specks become apparent on its surface, and when the material is subjected to some shades of the dyeing process, these specks, having no attraction for colour, entirely disfigure the appearance of the fabric. In half-ripe cotton we observe the connecting link between those fibres just described and those which are perfectly developed. While the unripe cotton is tissue-like in formation, and presents little or no appearance in the thickness of the walls, the half-ripe fibre is more clearly defined, and the deposit of matter on the inner surface is observable. It has also an approach to a convoluted structure, and seems to possess some tenacity and strength of which the other is entirely devoid.

18.—In Fig. 14, we have a microscopic illustration of the general appearance of unripe fibre, in which the peculiarities we have been describing will be apparent. Fig. 15 (350 diameters), shows the contrast between immature, half-ripe, and fully matured cotton fibres, in longitudinal and cross sections. A represents the dead or unripe fibre, B the half-ripe, and C the fully matured. In the cross section of A, it will be observed that it is similar to a ribbon without any tube-like appearance whatever. B appears more cylindrical, the walls more

Fig. 14.

General form of immature fibre found in our supplies.

solid and thick, and the tube better defined. In c, the perfect (or approximately so) cross section is given. The outer walls, it will be observed, have still further increased in diameter, owing to the complete deposit of the oleaginous matter having been effected when in active circulation.

NATURAL AND ARTIFICIAL DEFECTS IN OUR COTTON SUPPLY.

19.—All cottons, irrespective of quality or variety contain either more or less natural impurities, and in

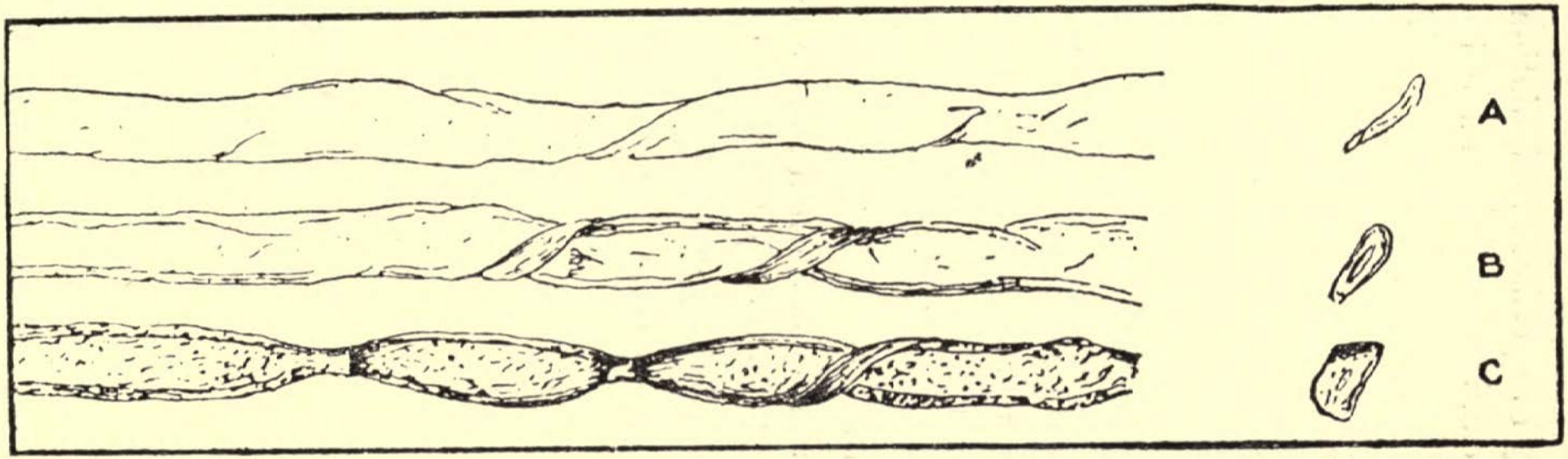

Fig. 15.—Representation of the three stages of growth in the cotton fibres, longitudinally and in section.
A, dead or unripe fibre. B, half ripe. C, fully matured.

addition, through imperfect manipulation (which, to a certain extent cannot possibly be avoided), their value is also reduced by the production of artificial defects in the structure of the fibres. Before proceeding to describe them in detail, we might summarise them as follows:—(1) Broken leaf, (2) seed, (3) sand and mineral matter, (4) short fibre, (5) unripe or undeveloped fibre, (6) broken or ruptured fibre, (7) stringy cotton, (8) natural nep, and (9) artificial nep.

The first of these defects is to a certain extent originated by the carelessness of the pickers on the cotton plantations, who, when plucking the cotton from the bolls, grasp at the same time the decayed leaves and remove the whole together.

As regards the second, when the cotton is removed from the boll, it is naturally dried and then taken and passed through a ginning machine, for the purpose of separating the fibres from the seeds to which they firmly adhere. As these machines are worked at high rates of speed, and often overcharged with material, the result is that a considerable number of the seeds, either whole or crushed, are carried through with the cotton, and go to swell the impurities in our cotton supply. Another reason why the process of cotton ginning is not carried out with the carefulness which the importance of the work demands is, that in the large majority of the growing districts, the gin factories are not owned by the agriculturalists, but by private capitalists, who receive the product of the plantations of several planters, to free from the seed, for which

they are paid at a certain rate. There is not therefore the same stimulus to use the cotton with greater regard to quality than to quantity and economy in the working, as when the planter prepares his own material for market.

(3) All cottons contain some percentage of sand and mineral matter, which, although not readily observable in the bale to the naked eye, becomes apparent after the material has been parted from it while in transit through the cleaning and scutching machine. The percentage which this class of impurity represents varies on average from 1¼ per cent to 4¼ per cent, the Sea Island cotton being most free from it, the American next, Egyptian third, Peruvian fourth, and the Indian varieties last. From a number of tests made to ascertain the percentage of this impurity, in the bales arriving at Liverpool in the ordinary course of trade, the following list was compiled:—

Sea Island Cotton	1·10	per cent.
Rough Peruvian	1·25	„
Gallini Egyptian	1·25	„
Brown Egyptian	1·60	„
Orleans	1·60	„
White Egyptian	1·75	„
Smooth Peruvian	1·80	„
Pernambuco	1·98	„
Texas	2·10	„
Upland	2·10	„
Bahia	2·16	„

Hingunghat	2·33	per cent.
Broach	2·58	„
Oomrawuttee	2·93	„
African	3·2	„
Dhollerah	4·10	„
Comptah	4·18	„
Bengal	5·3	„

In the adulteration of cotton, sand has also, like water, played a very prominent part, its great density and weight having no doubt recommended it for the purpose. Under any circumstances, however, all cottons contain more or less sand, the quantity increasing perceptibly if the picking is unduly delayed.

(4) As regards short fibre, there is in every pod when the plant has reached maturity an undergrowth of short hair on the base of the seed to which we have already made reference at a former part of this work.

(5) As to unripe fibre we have also already made sufficient explanation.

(6) The cause of broken or ruptured fibre in the bale is traceable to the action of the ginning machines, as, owing to great bodies or thick fleeces of cotton being fed rapidly into contact with the revolving rollers or saws of the ginning machines, with the fibres crossed and bent in every direction, the result is that there is always more or less damage done to the structure of the filaments, some, in fact, being completely broken. Long fibred cotton is always affected more in this respect than short, as it presents

a greater surface to the knives or rollers, and is more liable to get crushed.

(7) To much the same cause is the "stringing" of the cotton traceable, and also to being operated on too long by the saws or blades of the ginning apparatus.

20.—(8 and 9) In a former part of this work we have referred at some length to the variation in the maturity of the fibres in the same boll, and even on the same seed, when the cotton is ready for picking, and to the fact that in all cottons there is always more or less fibre in what might be termed a green state. The result of this is that when the circulation of the sustaining fluids is discontinued by their removal from the seed, they contract, curl up, and in this condition entwine and firmly attach themselves to the good fibre. When this happens they appear as small white specks or excrescences on the surface of the fibres, and are technically termed natural "nep." This class of nep is extremely difficult to remove, and even when it has been got rid of, it is at the expense of a considerable portion of the perfectly developed filaments, which would otherwise have been utilized by entering into the composition of the yarn. In spinning mills for medium and low numbers of yarns, and where only carding engines are used, cotton with any great percentage of this impurity can never be perfectly cleaned, as each individual fibre is not operated upon sufficiently; but in fine mills with combing machines, the defect is overcome, for while the fibres are held stationary, a revolving cylinder

filled with strips of fine needles is drawn through them, which carries away any fibre which falls below a certain standard in length, or any matter greater in diameter than that of the fibres.

Artificial nep is, in general, caused by imperfect manipulation in the cleaning processes, a defect which, strictly speaking, cannot possibly be altogether avoided, owing to the variation in the length and other characteristics of the fibre. There is, however, good ground for belief that at the great majority of spinning concerns, and at all the ginning factories in the cotton growing countries, the injury caused in this respect is excessive, and could by greater carefulness in the working, and a more intelligent knowledge of the structure of the fibre by those in charge of the various machines, be almost wholly avoided, or at least reduced to a minimum. Another cause of nep is owing to the pointed extremity of the fibre getting broken off while in transit through the cleaning machines. If carefully examined, even by the naked eye, it will be observed that the cotton fibre is not of equal thickness from end to end, but is shaped somewhat similar to a needle, that is, of equal diameter for about seven-eighths of its length, and then tapering to a point. This point is of course the apex of the fibre, and the one furthest removed from the seed when in active growth, and, instead of being tubular, is composed of solid cellulose. These points are therefore hard and rigid, and owing to their small diameter, they are, consequently, very weak. When therefore the cotton is subjected to the

action of the beaters these small points get broken off, and not being sufficiently heavy to be knocked or carried out with the other impurities, they attach themselves to the good cotton and turn up either in the after processes of manipulation, or pass out on the rollers with the short fibre, and form what is technically known as "flat waste." In fine spinning mills, where long fibred cotton is used, these fine points are more easily carried from process to process until they reach the combing machines, when every particle of them

Fig. 16.

Showing general form of the "nep," which appears as white specks on the surface of the thin web or fleece of the carded cotton as it leaves the doffer.

is almost entirely removed. The chief cause which produces "flat waste" is irregularity in the length of the fibres, as the long and strong have a tendency to throw out those which are shorter and less perfectly developed when in operation at the various machines. Where, therefore, great variation exists in the length of the filaments which compose the bulk, it will be easy to understand that the quantity of flat waste made in its manipulation will be correspondingly great, and, in addition to causing irregularities in the yarn produced from it, the cost of production will also be increased. Our illustration, Fig. 16, shows the appearance under the microscope of the general form of the nep, which show up on the thin web or fleece of the carded cotton as it leaves the doffer. It will be observed that they are tissue-like in their entire structure, and with only slight markings on their surface, conveying at once an idea to the examiner of their extreme weakness and utter uselessness for manufacture.

CHAPTER IV.

The Botanical Aspect of the Cotton Plant.

21.—Among the few botanists who have pursued and studied the cultivation of all the various varieties of the cotton plant, much difference of opinion exists regarding the proper classification and the number of species. Some investigators have asserted that there are over fifty distinct classes, while by others this number has been reduced as low as four. Dr. Royle, the eminent botanist, believed this latter opinion to be correct, and these he enumerates as follow:—

1. Gossypium Arboreum.
2. Gossypium Herbaceum.
3. Gossypium Barbadense.
4. Gossypium Hirsutum.

The first of these species, Gossypium Arboreum, so called from the great height to which it grows, is a strong, powerful, tree-like plant, reaching from twelve to eighteen feet. The hairy covering in which the seeds are encased is in this species of a greenish colour, and usually very coarse, and the fibres, therefore, difficult to remove. It is a native of Ceylon, Arabia, India, Egypt, and China. Unlike almost all other varieties of the cotton plant, its flowers, when in

blossom, are of a reddish colour. Fig. 17 gives an illustration of this plant.

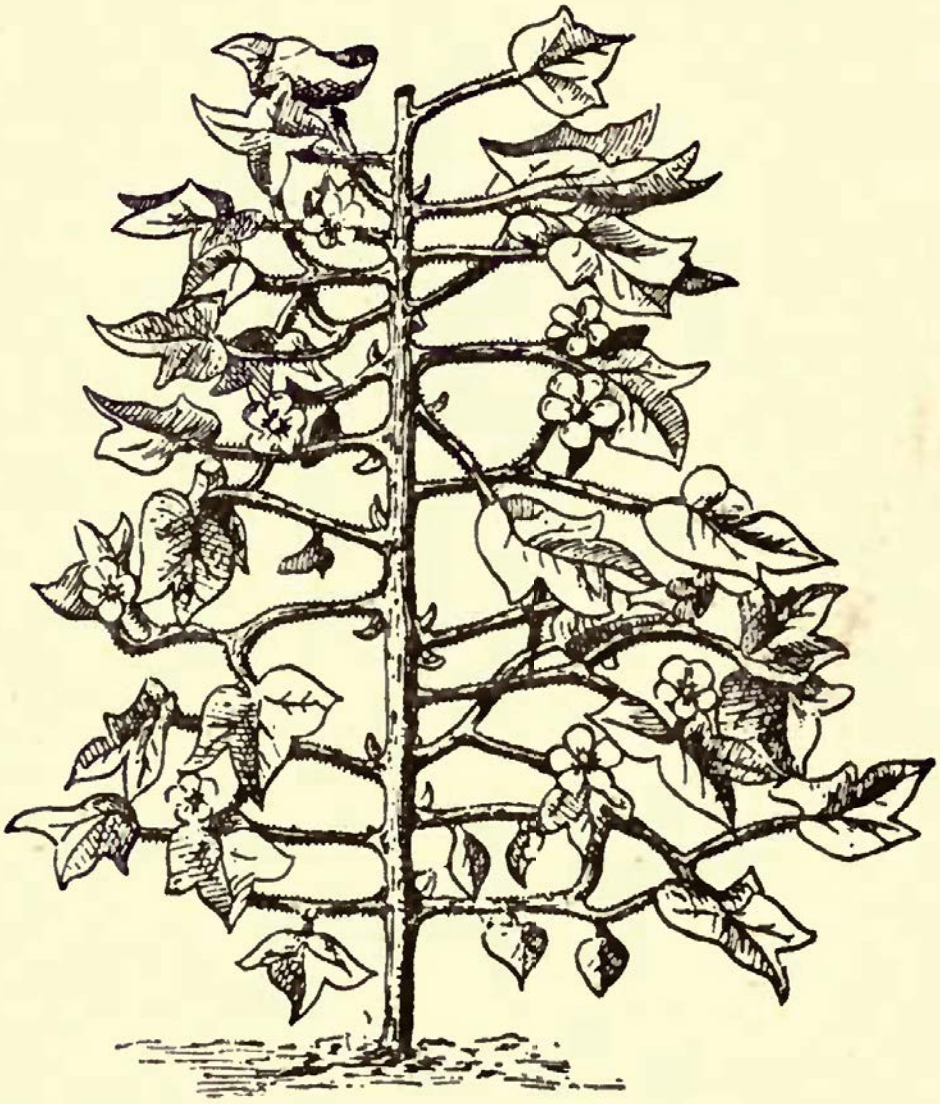

Fig. 17.
Gossypium Arboreum (Tree Cotton).

The Gossypium Herbaceum is a short hardy species, growing from three to six feet high when fully matured. It is an annual plant, or, in other words, a fresh crop requires to be raised every year. The seeds of this variety are generally covered with a soft, short down, particles of which are often removed with the

fully developed fibre, reducing the working qualities of the material. Eight months is the average time which this plant requires between beginning of germination and the perfect development of its

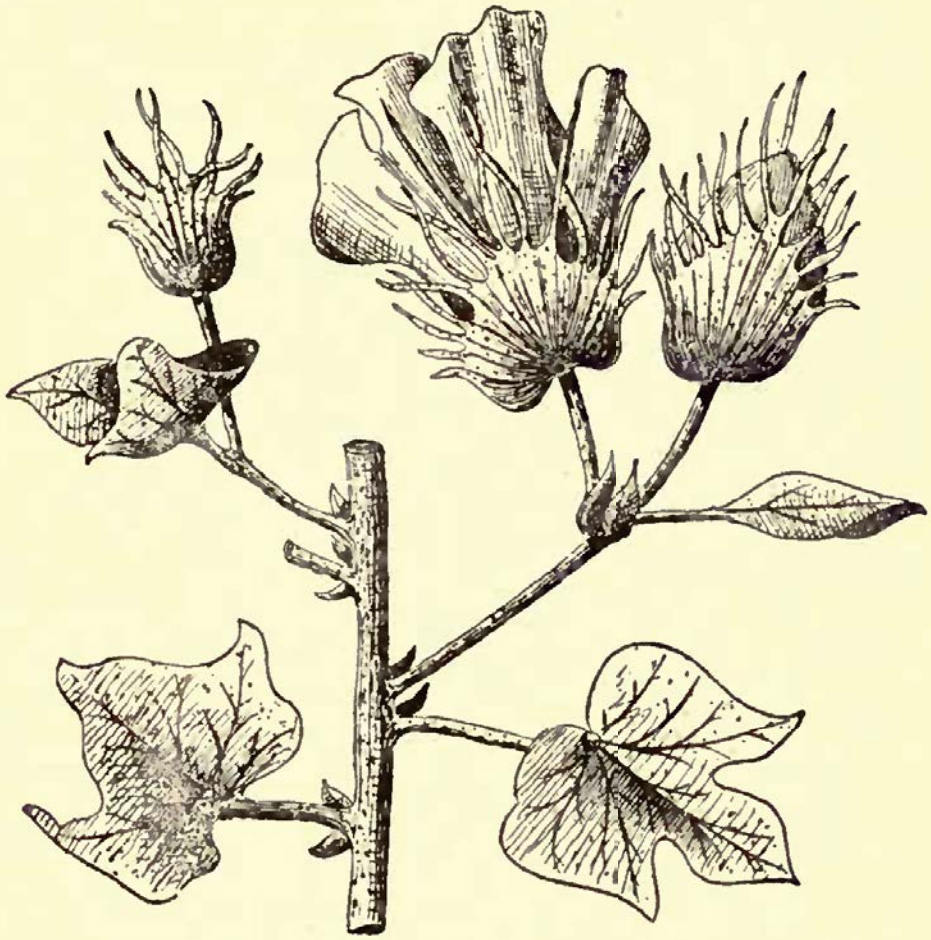

Fig. 18.

Gallini Egyptian Cotton Plant

capsules. The flower, when in bloom, is yellow in colour. As this species is of a much hardier nature than any of the others, it can therefore be, and is, cultivated over a much wider range of latitude. From it we obtain the Surat cottons, and, in fact, almost the entire quantity of our Indian supply.

22.—The Gossypium Barbadense species comprises the valuable, long, silky-fibred cottons grown on the

coasts of Florida and Georgia, the Barbadoes cottons, the Gallini Egyptian cottons, and all those known under the title of Sea Island. The colour of the blossom of this variety is yellow, like that of the Gossypium Herbaceum, but unlike it in shape, and as regards its seeds, which are entirely destitute of the undergrowth of fine down. The plant grows on an average to a height of from five to eight feet. During the last twenty or thirty years its seeds have been introduced more or less into almost all other cotton-growing countries, on account of its general superiority over other species. Our illustrations, Figs. 18 and 19, represent this plant in blossom, Fig. 18 being the present Sea Island, Gallini Egyptian, and other plants of this description, and Fig. 19 the original Barbadense plant. The plants classified under the Gossypium Hirsutum species are of a shrubby appearance, their maximum height being only about seven feet. The pods are hairy, and the seeds have a covering of fine greenish tinted down under the fibres of the cotton proper. From this species much of the Upland and Louisiana cottons are obtained. Professor Parlatore, a recent and reliable authority on the botanical relations of the cotton plant, enumerates seven primary species which he believes embrace every variety of commercial cotton. These he classifies as follow:—

1. Gossypium Barbadense, embracing the long-stapled Barbadoes, Sea Island, Egyptian, and Peruvian cottons.

2. Gossypium Herbaceum, embracing the cottons of India (Surat), Siam, China, Italy, etc.

3. Gossypium Hirsutum, the original cottons of Georgia, Louisiana, Bourbon, and also that variety known in commerce as Uplands.

4. Gossypium Arboreum, found in Ceylon, Arabia, Senegal, etc.

5. Gossypium Peruvianum, embracing the native varieties of Peruvian and Brazilian cottons.

6. Gossypium Tahitense, found in Tahiti, the Society Islands, etc.; and,

7. Gossypium Sandwichense, including the cottons found in the Sandwich and adjacent Islands.

The Gossypium Peruvianum is a plant indigenous to the soil around the shores of South America, but more especially to that portion of the country under the tropics. Its cultivation is carried out to a great extent in Peruvian and Brazilian plantations, where it attains to a height of about ten feet. Unlike the Egyptian, American, and Indian cottons, this species is perennial, flowering and bearing fruit for several years in succession, although, as a general rule, the best crops are obtained in the second and third years of growth.

The briefest, most comprehensive, and most easily understood classification of the different varieties of the cotton plant is that of (1) the tree, (2) the shrub, and (3) the herbaceous species, as within this division every known specimen of the plant is embraced. The tree species include all the strong powerful plants

which attain almost to the height of trees, say from ten feet upwards, independently of their location, or the source from which the seed may have been obtained. The shrub species includes all the short, bushy and dwarf-like plants, while the Herbaceous variety is the great source from which the supplies of commercial cottons are drawn.

In botanical circles, cotton is known as the product of a family of plants belonging to the natural order Malvaceœ, or Mallows, the generic name being Gossypium. The plant, although indigenous to almost all warm climates, is nevertheless only cultivated within a very limited area for commercial purposes, the principal centres of cotton agriculture being in Egypt, the Southern portions of the United States, India,

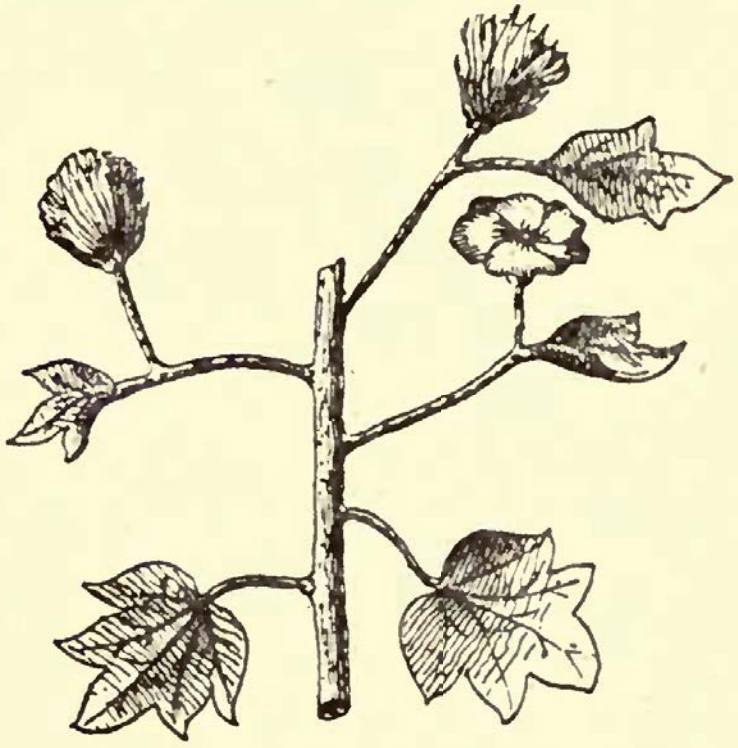

Fig 19.
Original form of Gossypium Barbadense Plant.

Brazil, the West and Southern Coasts of Africa, and the West India Islands. A large amount of white cotton is raised in China, but this is almost entirely used in the home manufactures.

The Phenomena of the Mechanical Structure and Growth of the Cotton Fibre.

23.—No other similar botanical subject lies under so deep a cloud of uncertainty as the growth and formation of the cotton fibre within the boll or pod. Theories which have been formed are all open to dispute, and the most untiring investigations have had no practical result.

That the cotton fibre is a flattened hollow ribbon or collapsed cylindrical tube, twisted many times (say 200 to 250) throughout its length, and not as it appears to the eye, a solid cylindric, gossamer-like hair is well known, but the cause of the twist, and the construction of the fibre have not yet been determined. The fibre is fairly uniform in diameter, terminating at the apex in a point containing solid oleaginous deposit. In growth this point is furtherest removed from the seed. With the growth of the plant comes the blossom and these are succeeded by the pods or bolls. The cotton pod consists of a hard outward skin or shield of a deep green colour, and about one-eighth or three-sixteenths of an inch thick, which is divided longitudinally into cells, generally three or four in number, according to the species of the plant.

From each valve a rib projects inwards and divides the pod into separate compartments in which the growth and formation of the seeds take place. In describing the theory of the seed development, Dr. Bowman says: "In the earlier stages of growth the seeds appear to be attached to the inner margin of the capillary septa, at the point of junction of these septa, that is to say, at the inner side of the carpel, where the two edges of the capillary septa unite, and they are connected to it by vascular bundles which proceed from below upwards, traverse the carpels, and send a branch to each seed. At the same time there is also a considerable development of cellular tissue, forming a ridge or placenta on the margins of the septa to which the seeds are attached. The seeds continue this attachment until they have attained their full size, and the growth of the hair on the surface of the seed has commenced. It then becomes gradually absorbed, and the seeds themselves are forced into the centres of the cavities by the gradual development of the hairy covering."

The formation of the seeds appears to be effected by the successive deposit of concentric layers of a solidified waxy substance, a point which will be easily understood by merely dividing a cotton seed in a cross direction. The outer layer is deposited first and the others in succession as the plant approaches nearer to maturity, until only the small centre cavity of the seed is left. This cavity, when the seed is attached to the septa and the vital fluids in active circulation, is

filled with a liquid oleaginous milky substance which becomes concreted as growth ceases. (See the composition of the wax of which the seeds are composed.)

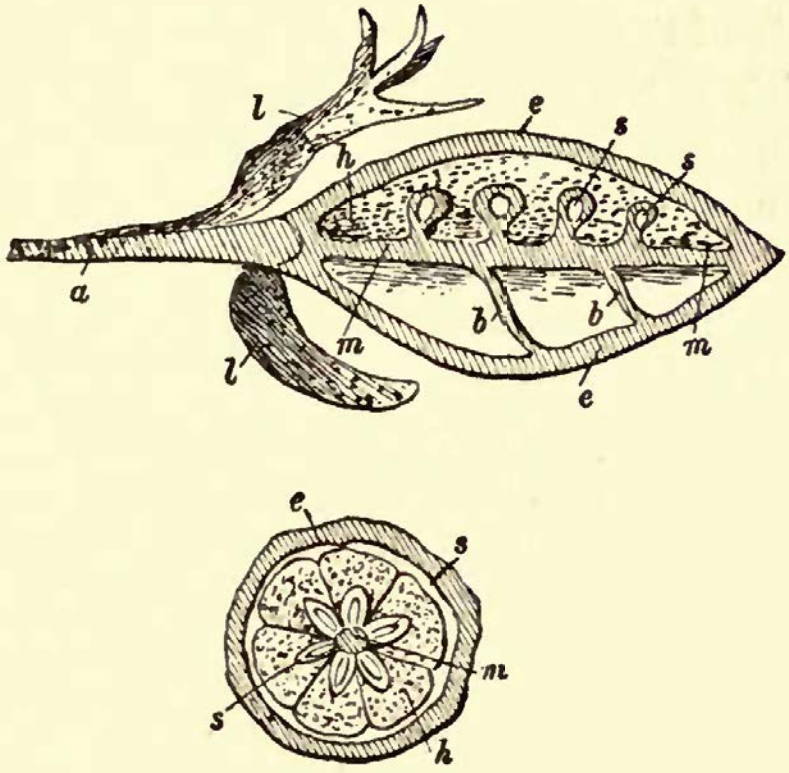

Fig. 20.

Longitudinal and transverse sections of a Gallini Egyptian specimen.

In Fig. 20 we have an illustration of a longitudinal and cross section of a cotton pod. The seeds shown at s are encased in a plexus of young fibre, H. The seeds, seed beds, and young fibre are immersed in a milky oleaginous fluid, from which the necessary nourishment for the development of the fibres is abstracted.

24.—As regards the formation of the fibres, the generally accepted description is that given in my former book, as follows :—

Growth begins on the surface of the seed at the opposite end to the point of attachment, some considerable time before the development of the seed is

complete. The construction is effected by the successive formation and deposit of a number of cells, one above another, on the dermal covering of the seed inside the cells of the capsules. As growth progresses the parts of the walls of these cells which are in contact with one another begin to corrode, and this corrosion goes on until they gradually become absorbed and disappear entirely, leaving one long extended cell or fibre behind. In this condition the fibre is perfectly hollow and cylindrical, with the outer walls thin and transparent, and the vital fluids (which are composed of a creamy coloured oleaginous matter) in active circulation within them, but as circulation goes on the inside surface of the wall becomes what I might term incrusted with a residium of the viscous matter, and so increases in density and thickness. As the plant approaches to perfect maturity the circulating fluids are gradually withdrawn from the fibre into the reservoir situated in the centre cavity of the seed. By this suctorial action, a vacuum is gradually caused, beginning at the apex and following the retreating fluid to the base, so that under atmospheric pressure the outer walls gradually collapse and cause the fibre to assume the form of a flattened and hollow ribbon. This now perfectly constructed fibre is composed of four distinct parts--(1) an outside membrane which forms the hard outside skin of the fibre ; (2) the real cellulose or oleaginous deposit which forms about 85 per cent. of the fibre ; and (3) a matter secreted in the centre tube similar to that which occupies the core of

a quill. Covering the outside membrane is what we might term a viscous varnish, but what is generally known as cotton wax. This wax amounts to about two per cent. of the fibre, and in the spinning of the material, it requires, by the heated temperature of the room, to be reduced to a certain point of liquefaction before it can be made to work properly without licking and lapping on the drawing rollers of the spinning machines. The presence of this oleaginous covering of the fibre can be observed by merely pouring on water on a sample of cotton. In so doing the water will retain practically no hold upon the fibre, but run off in somewhat the same manner as from the feathers of a duck. Cotton, if not previously bleached, never takes dye in a perfect manner, owing to the repulsive nature of this oily covering. The cellulose matter contained in the fibre is soluble under treatment with several reagents. This part of our subject concluded, we are now brought to a consideration of the origin of the natural twist and the serrated edges. As regards the former, it would appear that the rotary motion begins with the process of vacuation in the fibre, and as this is effected slowly and progressively, beginning near the extremity furthest removed from the seed, and gradually receding towards the base, the free end or point of the fibre, becomes twisted on its own axis several times, thus producing the flattened colvoluted form as exhibited under the microscope. As to the origin of the serrated edges, ocular demonstration can be obtained by the examination of an ordinary sample of cotton

banding which has been flattened by weight or pressure. Each strand, it will be observed, has by the operation of twisting been built in a spiral form one above another, thus giving the surface a corded or corrugated appearance. In a similar manner with the cotton fibre; as the vital fluids begin to be absorbed by the seed and a vacuum formed, the walls which are then of considerable thickness are bent and twisted upon themselves, producing this necessary and important characteristic to which we have occasion to refer several times in this work.

This is the description which has been generally accepted by authors and investigators, but Mr. W. S. Taggart, in his book on Cotton Spinning, ridicules the theory, and gives one of his own. He says, "When maturity is reached the circulation ceases, and the fluid interior is withdrawn by the seed or *disappears in some other way*, so that the tube gradually collapses through the pressure of the atmosphere into a ribbon-like thread with thick rounded edges, and in doing so yields in the weakest, and most probably the thinner parts, first at the outer end, and from here travels down to the seed along the line of least resistance. It almost follows from this statement that a more or less spiral twist would be the result."

I do not suppose that Mr. Taggart has had an opportunity of actually studying the growth of the plant, but, whether or not, I fail to see how his theory could produce twists. The vague wording which I have italicised is sublimely indefinite, and without better reasoning I think the present generally-

accepted explanation of the growth of the fibre will continue to exist.

25.—During growth the formation of the leaves and the development of the boll is an interesting study. The leaves vary in shape on different parts of the stalk. On a Gallini Egyptian plant the lower leaves were entire, the centre or middle three-lobed, while the upper leaves were five-lobed. In some of the American species the lower leaves have five and some three lobes, with the small branches and petioles of a hairy nature, while the upper leaves are entire and undivided. In the Peruvian cotton plant the lower leaves are entire and of an oval shape, while the upper leaves have five acuminated lobes. Another interesting point observable in the growth of the cotton plants is the presence of a small cavity situated at the lower end of the main vein under each leaf. Through this opening on warm days the plant discharges any excess of the resinous matter which circulates through its branches. Before the plant attains to its full height it begins to throw out flower stalks, which are generally (when perfectly formed) small in diameter and of considerable length ; on the extremity of these stalks the blossom pod after a time appears, encased in three leaf-shields or calyces, with fringes of various lengths, as shown in our illustration of Gallini plant. Gradually this pod expands till it attains to about the size of a bean, when it bursts and displays the blossom, as shown in the same illustration. This blossom only exists in full development for about twenty-four hours, when it begins to revolve imperceptibly on its

axis, and in about a day's time twists itself completely off. When the blossom has fallen, a small three, and in some cases four-celled triangular capsular pod of a dark green colour is disclosed, which increases in size till it reaches that of a large filbert. Meantime the seeds and filaments have been in course of formation inside the pod, and when growth is completed, the expansion of the wool causes it to burst into sections, in each cell of which, and adhering firmly to the surface of the seeds, is a tuft of the downy material.

Analysis of Cotton Fibre and Seed.

The latest analysis given of the cotton fibre taken from the bale is :—

Carbonate of Potassium	32·22	per cent.	soluble	in water.
Sulphate „	13·02	„	„	„
Chloride „	10·21	„	„	„
Carbonate of Sodium	3·35	„	„	„
Carbonate Calcium	20·26	„	insoluble	„
Phosphate of Magnesium	8·73	„	„	„
Carbonate „	7·81	„	„	„
Peroxide of Iron	3·40	„	„	„

The walls of the cotton fibre consist of 85 per cent. of cellulose, and in Dr. Ure's analysis, which has much in common with the above, he remarks that "It seems to throw considerable light on the predilection of the cotton plant for the neighbourhood of the sea, which supplies plentifully the saline substances requisite to the perfect development and constitution of its woolly fruit. It may hence be inferred that

the compost or manure best fitted for cotton plantations should contain neutrosaline matter with alkaline, calcareous and magnesian bases. The presence of magnesia deserves notice, as it indicates marine food. Here, as in many other examples, the vegetative powers of the roots seem to eliminate potash from the stone detritus of the soil, which replaces the soda in the sea salts ; for otherwise we should have found salts with a basis of soda, instead of potash salts in the ashes of the cotton.

The chemical formula for celluloise is $C_6 H_{10} O_5$, or—

Carbon	44·44
Hydrogen	6·17
Oxygen	49·39

The composition of the wax of which the seeds are composed differs to a slight extent in different varieties. American cotton seeds showed the following result :—

Carbon	81·00 per cent.
Hydrogen	14·80 per cent.
Oxygen	4·82 per cent.

Cotton seed wax solidifies at a temperature of about 175 F., and fuses at 190 F.

Sea Island.

26.—Of all the numerous varieties of cotton imported into our markets, this species is by far the most superior. The chief points in which it excels other cottons might be enumerated as follow :—

1. In length, being five-eighths of an inch longer than the average cottons ;

2. In smallness of diameter being much finer ;

3. In the number and regularity of the natural twists ;

4. In being adapted (owing to its fineness) to produce a strong yarn, more fibres lying in each cross-section of the thread than is the case with other cottons ;

5. In colour, being much silkier and more glossy.

In colour, the Sea Island cotton is of a light creamy silk, while in general appearance it is very clean, that is, as regards freedom from broken leaf, seed, earthy, and other foreign matter. Unfortunately, however, the value of many deliveries is materially reduced owing to the damage which the fibre has sustained when passing through the ginning machines, as the parts, running at a high speed, have, from the great length of the fibre, a tendency to string the cotton, and rupture and break the staple, thus, not only reducing the percentage of its strength, but also increasing the difficulties of manipulation, as it is impossible for short or broken fibre to work satisfactorily with the long ; and in addition, the cotton rendered stringy or matted by the action of the gin, can never be opened or carded in a manner sufficiently good to insure the production of a high-class yarn.

In Fig. 21 we have a very clear microscopic illustration of this variety. From it, the spiral form and the regularity of the natural twist, to which we have already referred, will be observed. When examining the fibres of this variety of cotton under the microscope, and on the lines of the micrometer glass, the

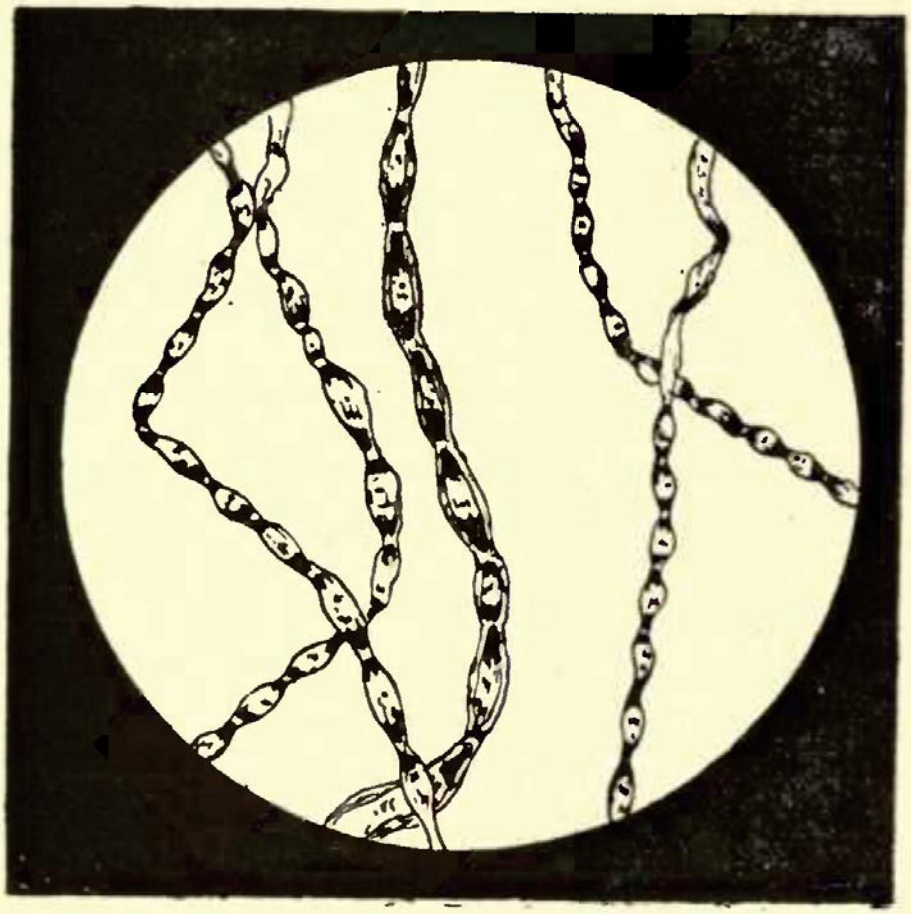

Fig. 21.
North American (Sea Island).

student cannot fail to notice that they vary considerably in diameter.

The middle fibre shown in the illustration, it will be observed, appears much larger and more rigid than the others, while also the outer walls are stronger and coarser. It is, of course, an exception to those which constitute the general bulk of the material, and my only object in introducing it, therefore, is merely to show the great contrast in their structure.

This variety of cotton is the most valuable part of the product of the Gossypium Barbadense species. In treating of the Sea Island cotton, it would perhaps

be advisable to explain the causes which contribute to its general excellence and superiority over other varieties. These are, therefore, as follow :—

1. Better seed ;

2. Most suitable soil, for the successful cultivation of the plant, which, by the way, is a light sandy alluvial deposit, containing a percentage of saline matter ;

3. Better irrigation and drainage ;

4. Greater care in its cultivation, and in the concluding operations of picking and ginning ;

5. A moderate and more equable climate.

Florida Sea Islands.—In the bulk, this variety of cotton appears to the eye to be similar to the Sea Island proper, and in reality they have much in common. The Florida cotton is glossy, smooth, and silky in appearance, and very strong. It, however, unfortunately often contains a considerable percentage of short, broken, and immature fibre, which, if drawn out between the fingers, will be found to be only about three-quarters of an inch in length. These generally adhere to the good and long fibres in clusters, and as there is no way in which their attachment can be released, they are thus very difficult to remove, and even when got rid of, it is only at the expense of much good cotton and workable staple. In some of the lower grades of this cotton, the quantity of neppy material is so great, and the particles of the congregated fibre in contraction so small and minute, that it is absolutely impossible to thoroughly clean the material, no matter with what care its manipulation may be effected. Under microscopic examina-

tion there is very little difference that can be detected between this and the preceding variety, so that the description there given can be applied equally in both cases. This species is also the product of the Gossypium Barbadense variety.

Fiji Sea Island.

27.—Like the two former varieties of cotton, the Fiji is also the product of the Gossypium Barbadense species, but it differs considerably from them in its appearance, both externally and internally, with the exception of its colour, which is of a light creamy and glossy silk, similar to the Florida cotton. It is also very clean, as regards freedom from foreign and earthy matter, but it is very defective in other respects, containing very large percentages of nep or contracted fibre, broken and ruptured fibre, and stringy, matted locks of cotton. When compared in strength with that produced on the native soil it is rather weak, nevertheless, it incorporates fairly well with it when a mixing of the two kinds has been made. In length, the staple is very irregular, which, of course, is the means of causing a great amount of waste in the working.

When viewed under the microscope, the Fiji variety of cotton is shown to be less regular in the number and roundness of its natural twists than either of the two preceding cottons, and the deposit of matter on the inner surface of the fibre walls does not appear to have been so great. Our illustration, Fig. 22, exhibits these features.

Gallini Egyptian.

This variety of cotton is the product of the Gossypium Barbadense species, having been originally raised from the Sea Island seed imported into Egypt. Although it is inferior to the cottons we have already

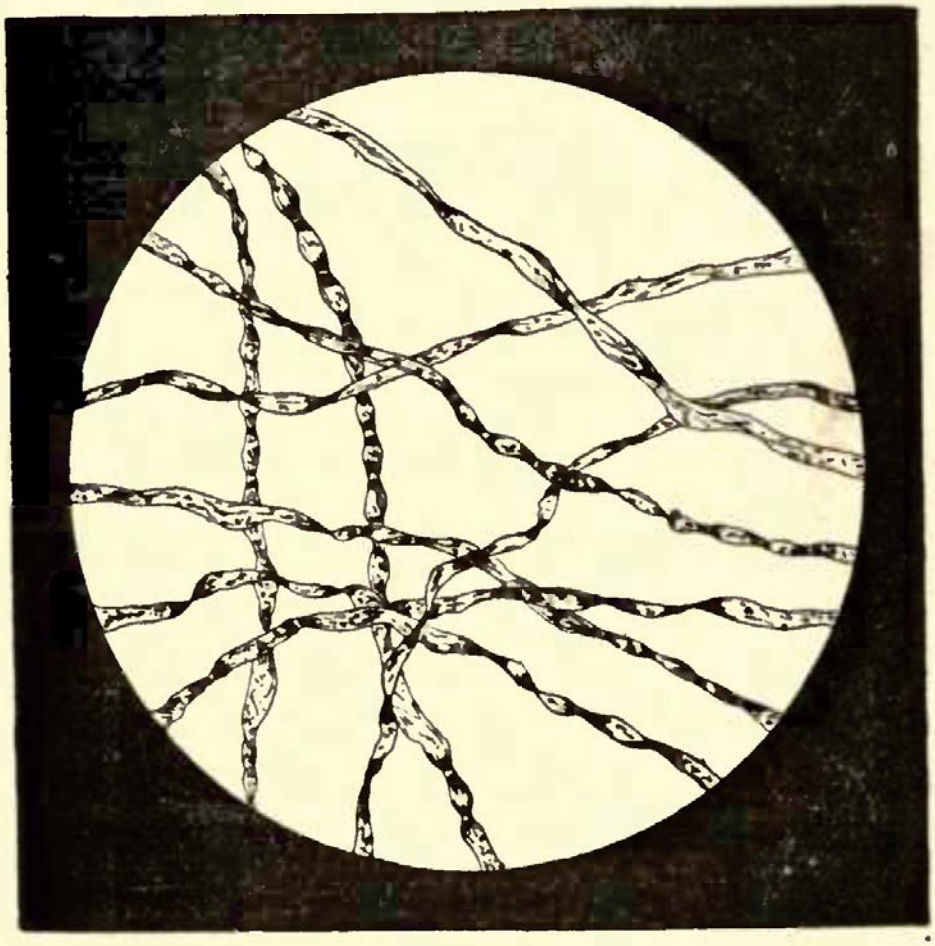

Fig. 22.

Fiji Sea Island Cotton Fibres.

described, it nevertheless forms a very important connecting link on the scale of quality between them and the succeeding varieties. All deliveries of Gallini cottons are of a golden colour, or approaching thereto, a characteristic which precludes them from being

used in conjunction with the product of any other country. There are, of course, several grades of quality, and these can be blended together to suit different yarns. The fibres of the general crop of this plant are very fine and remarkably tough and strong, which are two of the highest recommendations any cotton can possess. There is, however, a considerable quantity of undeveloped and short fibre found distributed throughout the bulk, and, in addition, many of the crops (especially those of the lower grades), when sent into our markets, are found to contain much broken leaf and crushed portions of seeds, defects which, of course, reduce their value and lessen the price which they would otherwise command. As the fibres, however, are not so often and so regularly twisted in their natural form, and not of so small a diameter as the Sea Island cottons, the immature and contracted fibre is much more easily got rid of in the various cleaning operations of the mill than these varieties, and at less cost or damage to the good staple.

The yarns for the production of which the Gallini cottons are chiefly made applicable range from 70 to 120 hanks to the pound, according to the grade or standard of quality of the material. Frequently the mixings are composed of two kinds, say half the finest or second rate, and the other half a third or fourth rate quality, for yarns of lower counts.

Under microscopic examination the fibres of the Gallini cottons appear to be fairly regularly twisted, although, there are, of course, a number of exceptions

in the shape of flat, ribbon-like fibres. The fibre walls, although harder and denser than those of the Sea Island variety, are nevertheless very fine ; and the deposit of matter, when the fibre has been in active growth, does not appear to have been so regularly distributed or so perfect. Our illustration, Fig. 23, shows these characteristics, and if placed in comparison with Figs. 21 and 22 of the Sea Island

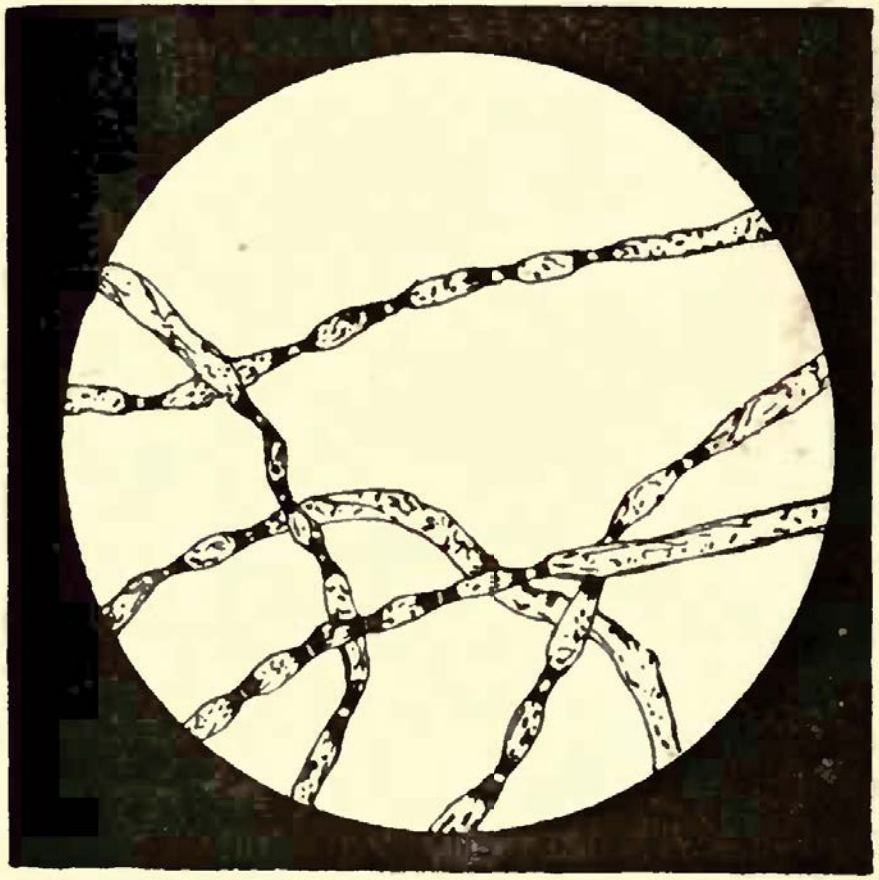

Fig. 23.

Egypt—Gallini.

varieties, the peculiarities of each will become more apparent. On the lines of the micrometer glass the diameters of the different fibres I find vary remarkably little.

Peruvian Sea Island.

28.—Like the Gallini species, the seed from which this cotton is raised is not indigenous to the country, but was originally imported a few years ago from the plantations of Georgia and Florida. Its general qualities are of a fairly high standard, although, when placed alongside the product of the shrub grown on its native habitat, it neither looks so glossy and silky, nor the fibre so fine, but appears more harsh, hairy, and inflexible. The colour is of a slightly golden tint, and, I find, varies in degree to some little extent in different crops, and in the product of different districts. The strength of the fibre is only of a very moderate character, much weaker, in fact, than the preceding varieties, although the diameter is rather greater. All deliveries of this cotton are also much dirtier, the lower ones especially being often highly charged with leaf, seed, sand, and other foreign matter, a defect which might to a very great extent be easily corrected, if only a little more care and thoughtfulness were bestowed by those engaged in gathering the crop and preparing it for market. In addition to being also sometimes rather dirty, it always contains a considerable quantity of short, broken, and undeveloped fibre, but in this latter characteristic, it is in no way inferior to that produced on the parent soil, but is, in fact, often superior to the Florida variety.

Under microscopic examination I find that the outward appearance of the fibres of the Peruvian Sea

Island is fully borne out by the characteristics and peculiarities of their inward structure. Under a power of, say 250 diameters, the structure appears much harsher than that of the Sea Island proper, and although the bulk of the fibres are, comparatively speaking, of a regularly convoluted form, yet the exceptions are much more numerous than in either of the foregoing varieties.

Tahiti Sea Island.

This variety is also the product of the Gossypium Barbadense species, the seed having been introduced from Georgia and Florida some few years ago. Its cultivation is not carried on to a very great extent, although the planters have been enabled to produce a cotton which ranks about sixth on the commercial scale of quality. In general, the crops of this cotton when sent into our markets are very clean, that is, as relating to foreign and earthy matter ; but they unfortunately contain a large percentage of fibre which is unripe, broken, or ruptured, and formed into matted and stringy locks. The former of these defects is caused by an excessive undergrowth of short hair on the seed, which has been removed and carried through with the long cotton during the operation of ginning ; while the others are, in a great measure, artificially produced by the process of ginning.

The colour and appearance of the Tahiti Sea Island cottons is of a glossy, creamy silk, greatly resembling the Fiji Sea Island already described. Like it, also, the fibres are rather irregular in length, so that, as it

has been found from experience in working that long fibres do not incorporate well with those that are short, but have a tendency to throw them out, the waste made in its manipulation is comparatively great. In strength it is rather weak, and consequently not well adapted for the production of twist yarns.

When examined under the microscope, the general bulk of the fibres is shown to be of a spiral form, although there are also a large number of tissue-like filaments and flattened untwisted cylindrical threads. The short, immature fibres, which we have spoken of as an undergrowth of the seed, appear as partially, and in some specimens wholly transparent, with the walls very thin, and no approach to a hollow or tubular form. It is these thin and bodiless fibres which contract when subjected to the warm temperature of the rooms of the factory, and go to increase the quantity of "nep," to which all classes of Sea Island cottons are very subject.

Brown Egyptian.

29.—This cotton is now generally supposed by botanists and other scientists to be indigenous to Egypt, as its cultivation can be traced for several centuries back, and also to the fact that the fibres differ in many distinct points from the product of all other commercial plants. It is one of the products of the Gossypium Herbaceum species, and is chiefly remarkable for its fine golden colour, a peculiarity which is, however, not so high or decided as many imagine, or as its name

would lead one to suppose. Strange to say, the deepness of this tint is subject to variation in different crops, and even in different portions of the same crop which may be placed under different atmospheric influences ; the tint being lighter when the air is dry and warm, and darker when cool and moist. One very important quality which the Brown Egyptian cottons possess in a very marked degree is toughness and tensile strength, a characteristic which renders them admirably adapted for the composition of either twist or weft yarns, that is, for the longitudinal and transverse threads of the cloth in weaving. Cotton to be employed in the production of twist yarns must necessarily be considerably stronger than that which might be in use in the composition of weft threads, as at the loom the drag and strain placed upon the warp yarn is very great, while in comparison, the weft has practically no strain whatever exerted upon it. In general, all cottons of this class are very free from impure matter, such as seed, leaf, or sand ; but, unfortunately, their working properties are often depreciated somewhat by the appearance of unripe or undeveloped fibre. In comparing the fibres of this and the Gallini cottons, it will be found that the former is much shorter and rather coarser, so that the filaments do not appear to lie so close to one another. Owing to its peculiar colour, it is, of course, precluded from being mixed satisfactorily with other cottons.

In examining Fig. 24, the greater density, diameter, and less spiral form of each individual filament than those in former illustrations will be ob-

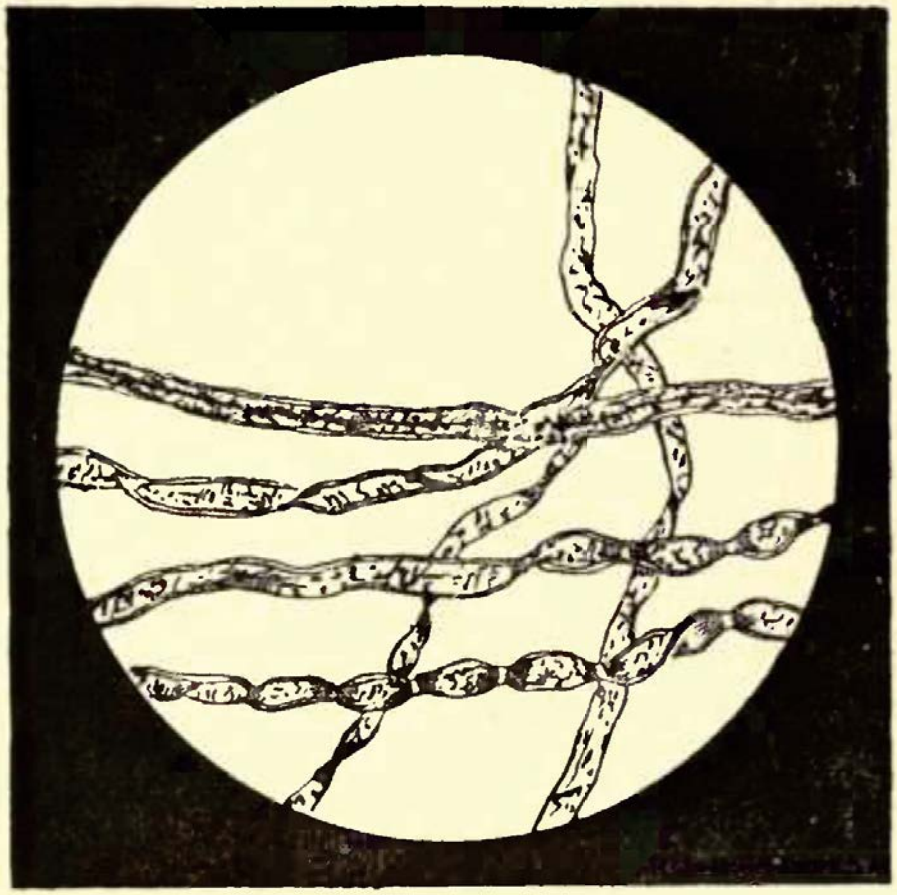

Fig. 24.

Egyptian—Brown.

served. The fibre walls appear also more harsh, and less elastic and flexible than those of the preceding variety, although both are grown on similar soils and subjected to the same methods of cultivation.

Rough and Smooth Peruvian.

30.—*Rough Peruvian.*—To Brazil and Peru this variety of cotton is indigenous, forming one of the products of the Gossypium Peruvianum species. Unlike the general form of the cotton plant cultivated throughout the various districts of the world, this plant is

perennial, bearing good crops for several years in succession, although the best and most productive are those obtained during the second and third years of growth. The reason of this is that with only one year's cultivation the plant has not fully developed itself, consequently it requires the sap for its own growth which would otherwise be absorbed in producing and ripening the pods. There are, of course, in about nine or ten months after planting, stalks thrown out, on which the blossoms are followed by the pods, but from this cause their growth is stunted, and the yield of fruit consequently *nil*. After the third season has passed, the sustaining fluids of the plant begin to get exhausted, so that the pods gradually deteriorate in size, and the cotton to get harsher, drier, and more brittle, until in about five or six years the fibres approach in many respects the structure of the wild cotton, and it is therefore of no use for manufacturing purposes. Rough Peruvian cottons, when at their best, are of a light creamy colour, and soft to appearance, but to the touch they feel harsh and hairy, and the fibres do not adhere to one another so close or compactly as in any other cottons possessing similar properties, such as length of fibre, etc. One good feature about even every delivery of this class of cotton, and one which increases its market value considerably, is, that it is remarkably clean, only a very small percentage of leaf, seed, sand, etc., being distributed throughout the bulk. In this respect it presents a striking contrast to every other class of Peruvian and Brazilian cottons, with the exception of the

smooth or soft variety, and is a most economical cotton to work. As regards the strength of its filaments, it varies somewhat ; but, to take a general average, it could only be described as moderate.

Under microscopic examination I find that the fibres are in general only slightly or partially twisted, few of them being possessed of that perfectly con-

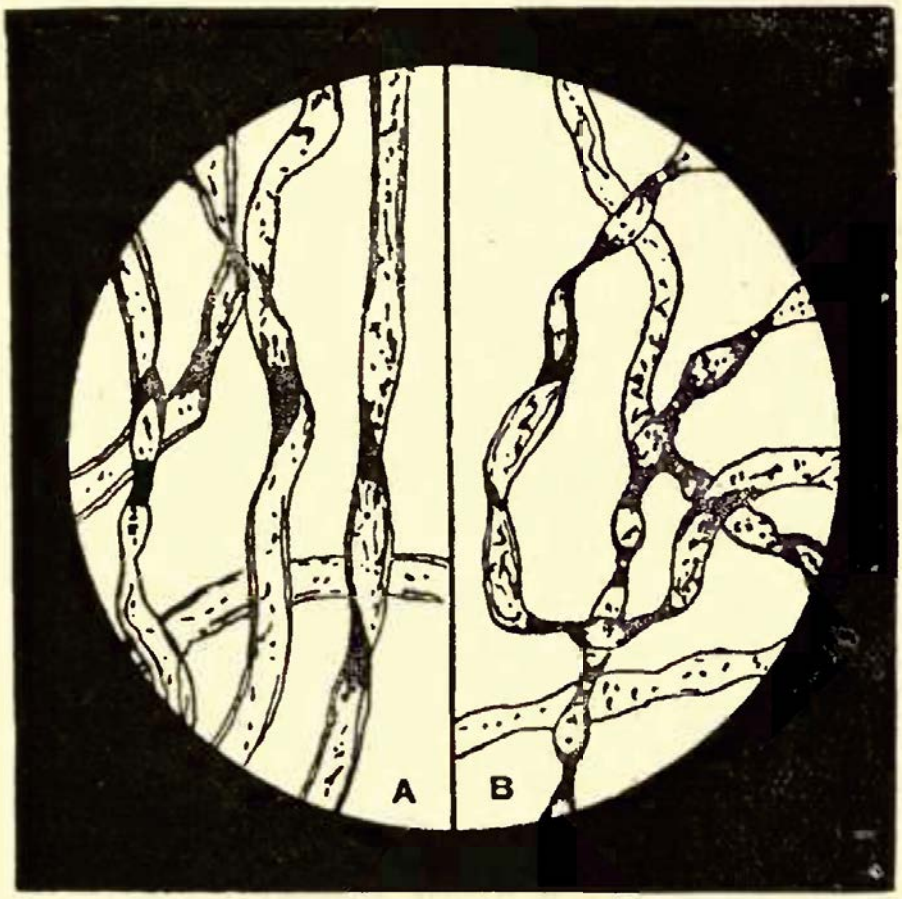

Fig. 25.

South American—A Rough; B Smooth Peruvian.

voluted form which characterises the Sea Island cottons. Many of them, too, I find to be semi-transparent, and to appear dry and brittle, owing, no doubt, to the insufficiency of the oleaginous deposit with which the inner walls should have been coated before growth had ceased. On A, Fig. 25, I give an illustra-

tion of the fibres of this species, the variable appearance of which is apparent.

Smooth or Soft Peruvian.—With the exception of the differences which their name indicates, there is very little else to outward appearance to distinguish between the rough and smooth varieties of Peruvian cottons, but in their character the difference is very great. In the former, as we have already stated, the fibres are harsh and hairy ; but in the latter they are very soft, smooth, and pliable. The smooth Peruvian is also the product of the Gossypium Peruvianum species, and the deliveries very free from foreign matter and artificial defects. In many crops, however, there is unfortunately a large percentage of "nep" (the technical name for the little white blotches or specks which appear on the surface of the cotton during manipulation, and on the yarn when not removed at the cleaning process), or unripe fibre, which reduces its value accordingly to a greater or lesser extent. Being soft, and as the staple is only of a medium strength, it is therefore best adapted for the production of weft yarns.

In colour it has a great resemblance to Orleans cotton, it incorporates freely with it, and increases the productive capabilities and the range of yarns to which the latter is suited very considerably when they are blended together in one mixing.

In B., Fig. 25, we have a microscopic illustration of the fibres of this cotton. In contrast with the "rough" variety the differences are easily made apparent.

White Egyptian.

31.—Following in order of value, or the commercial scale of esteem, we have the White Egyptian cotton, so called to distinguish them from the Gallini and Brown varieties already described. These are of two kinds, or rather the product of two plants, which are both exotics, and were originally distinct from one another ; the first, Gossypium Peruvian, being derived and introduced from the Peru plantations about eighty years ago, and the second, Gossypium Hirsutum, from the American plantations. Unlike that of the Gossypium Barbardense variety (Gallini cotton), the quality of the product of these plants has improved instead of becoming reduced by removal, in all probability owing to the climate being less subject to extreme variation, and also the soil being better adapted for the successful cultivation of the cotton plant.

In connection with these distinct species of the plant, it is worthy of notice that although the crops produced from them on their native habitat differ widely in appearance, structure, and formation of the fibre, and elasticity and strength, on Egyptian plantations they have become almost perfectly assimilated, and their general characteristics rendered uniform and similar in almost every respect. The white Egyptian cottons are, as a general rule, possessed of good commercial qualities, but each season's crops can, unfortunately, be divided into numerous grades, the middle and lower of which are often surcharged

with broken seed, leaf, and sand, owing, in a very great measure, to imperfect and careless picking, ginning, and packing. Even the higher grades are sometimes subject to these defects, so that our supplies from the same district, and even the same plantation, fluctuate in cleanness and quality to a considerable extent. The fibres of the white Egyptian cottons are usually fairly strong, and being also soft and pliable, they are very suitable for the production of either twist or weft yarns. The colour is of a very light golden tint in the middle and higher varieties, and of a whiter nature in the lower. All cottons of this class are well adapted for mixing with the product of American and Brazilian plantations, and are, in fact,

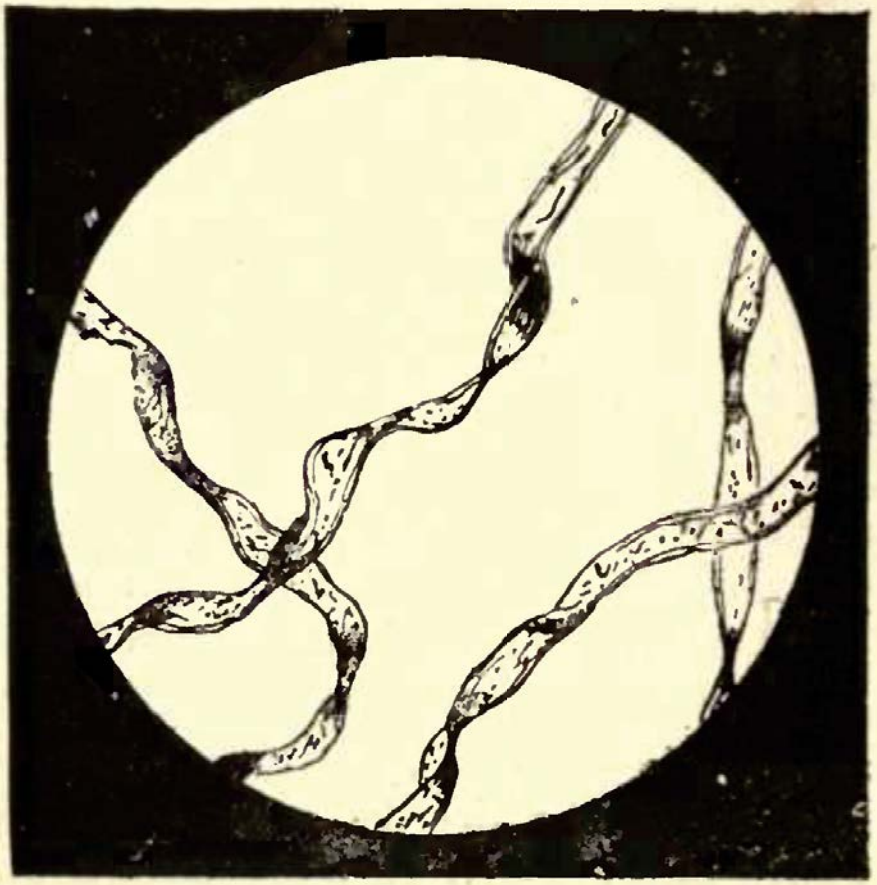

Fig. 26.
Egyptian—White.

greatly in use for this purpose. By themselves they enter larger into the composition of yarns, ranging from 40 up to 70 hanks to the pound, to be used in the manufacture of medium fabrics, and also in the weaving of what is known as "unions," *i.e.*, cloth composed of both linen and cotton.

Pernambuco.

32.—In this cotton we have the finest specimen of the Brazil crop, the fibres being longer and stronger than in any other variety of this countrv's product. Like the two preceding varieties it belongs to the Gossypium Peruvianum species, and is cultivated to a very considerable extent in and around Pernambuco, the port from which it takes its name. The colour is of a slightly golden tint, and resembling the white Egyptian cotton, but in comparison to it and the American cotton the Pernambuco feels harsh and wiry, and is therefore best adapted for twist yarns. Each season's crops are fairly clean, and in this respect superior to those generally of other districts, but in Brazil cottons there is always more or less variation, the plants, even in the same plantation, and treated in an exactly similar way, producing in different seasons cottons very dissimilar in many respects. The counts or numbers which the Pernambuco enters most largely into the composition of range from 40 up to 60 hanks to the pound, but it is often mixed with some of the varieties of the white Egyptian cottons, which by itself it would be unable to spin, and if all Egyptian were used the cost would be too high.

Under the microscope I have found that, as a general rule, the fibres of the Pernambuco cottons have a stronger and harder appearance than any yet described, while they contain fewer tissue-like shreds and less variation in the structure of each individual filament. The twists are large but well defined, and impart a regular and spiro-cylindrical appearance, which, with the thickness of the walls, no doubt give to the fibres the elastic harshness which one feels it possesses by merely examining it between the finger and thumb. Some fibres of this variety that I have observed had a perfectly convoluted structure, beginning with the end in focus at one side of the glass, and

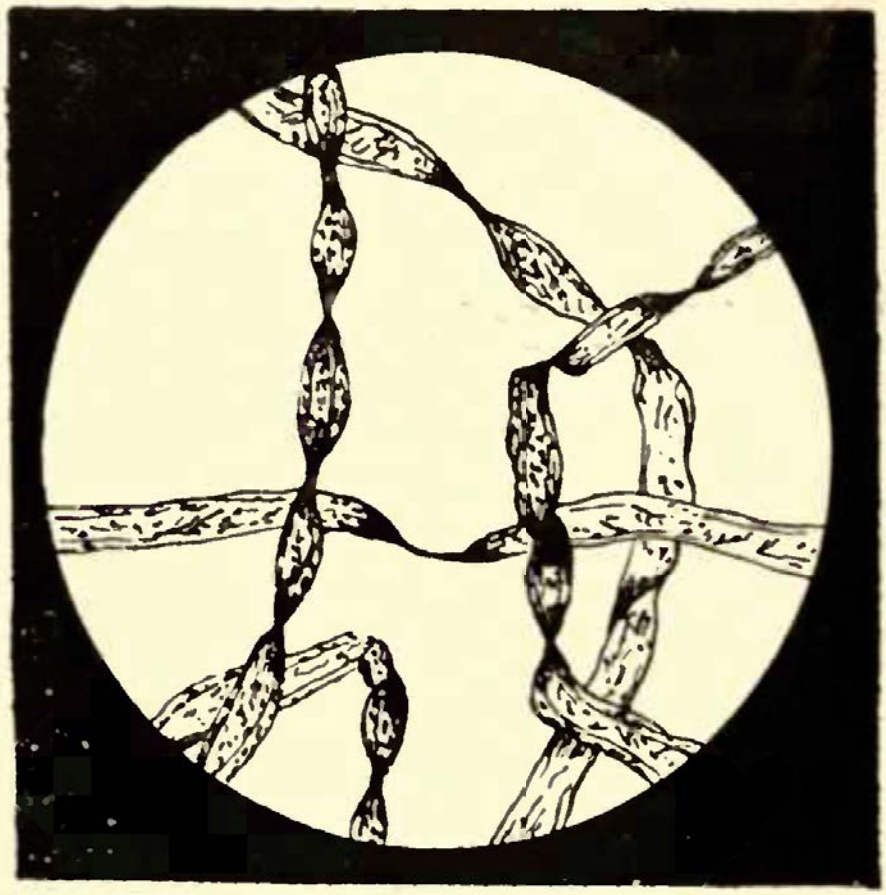

Fig. 27.
South American Pernambuco.

continuing right across the disc to the other. The fibres, absolutely devoid of this natural twist, must be very scarce, as only in two instances have I come across them. Fig 27 gives a representation of the Pernambuco fibres, which will convey a clear idea to the reader of these distinguishing characteristics. On the lines of the micrometer glass the diameter appears to average about the $\frac{1}{1270}$th or ·000,787 of an inch.

Maranhams.

33.—Following the Pernambuco cottons, this variety ranks next in quality, and generally commands even prices with it, or at least, very little lower, in our markets. Its general appearance is of a dull golden tint, and the fibres not quite so strong as that of the Pernambuco. Many deliveries are often unfortunately rather dirty, containing considerable percentages of leaf, seed, shell, sand, etc., but it is to the former of these impurities that each season's crops appear to be most subject. Owing, however, to improved methods of cultivation and ginning, and greater care being exercised in the picking operation, it is every year improving in this respect. The Maranham cotton can be, and is, often used with either Egyptian or American cottons when the colour and length of staple is approximately similar.

When examined under the microscope it will be found that the filaments have much in common with those of the preceding variety. The twists, however, are not quite so regularly distributed, but in other respects there is little difference noticeable. This

variety of cotton is also the product of the Gossypium Peruvianum species.

Ceara.

In this variety we have another production of the Gossypium Peruvianum species, and one which constitutes a very considerable proportion of the entire crop of Brazilian cotton. The medium and higher grades of the Ceara are in general fairly clean, in fact, in this respect superior to the Maranhams ; but in the lower qualities there is often to be found a considerable percentage of sand, leaf, and other unworkable matter. The colour is of a dull white, and there is considerable variation, which is its chief defect. The fibres are of a medium strength, and can, therefore, be adapted to either twist or weft yarns.

Orleans.

34.—In this variety we have the typical American cotton, and that which forms the most important portion of our commercial supplies. The plant, which is of the Gossypium Hirsutum species, is cultivated to a great extent in Mississippi and Louisiana plantations, while the large part of the product is exported to, and consumed in the manufactures of, this country. On the whole, the Orleans is the most perfect and finest of the white varieties of the American cottons, but being cultivated over a considerable extent of the southern portions of the country, there is, of course, considerable variation in the crops, and consequently there are numerous grades of quality sent into our

markets. In the finer qualities the fibres are very uniform in length, almost entirely free from tissue, and undeveloped filaments, and very clean, so that, therefore, it is a most economical cotton to work into yarn, and its natural qualities can be utilised to a greater extent than those of almost any other commercial cotton. In what is termed the lower grades, however, there is often a large percentage of broken leaf, seed, sand, etc., which renders them not so well adapted for economical or high-class manipulative workmanship. Owing to the great esteem which cottons of this class are held in this country, there is good reason to believe that the cottons of other American plantations are sent on to Orleans, and there receive the stamp or brand of that shipping port, after which they are sent to this country and fraudulently sold as the product of that district. This may account for the large quantity of the lower grades of this cotton which is always to be found in Liverpool, but to experienced buyers the fraud may be at once detected. In colour, the crops from different plantations vary somewhat, some being almost pure white, while others are possessed of a nice light creamy tint, a characteristic which enables them to be used either with Egyptian, Peruvian, or other kinds of the American varieties. The staple is of a fair strength, and consequently well adapted for the production of either warp or weft yarns, and in addition it is soft, moist, elastic, and pliable.

At the present time, in Lancashire concerns, it is largely used in the same mixing with the white

Egyptian variety, thereby reducing the cost of the product, and allowing a greater margin of profit on the working.

In Fig. 28 I give a microscopic illustration of the Orleans variety. In it the fibres are shown to be somewhat irregular in the character of their twist, but are, in general, spiro-cylindric in form : in fact, they are

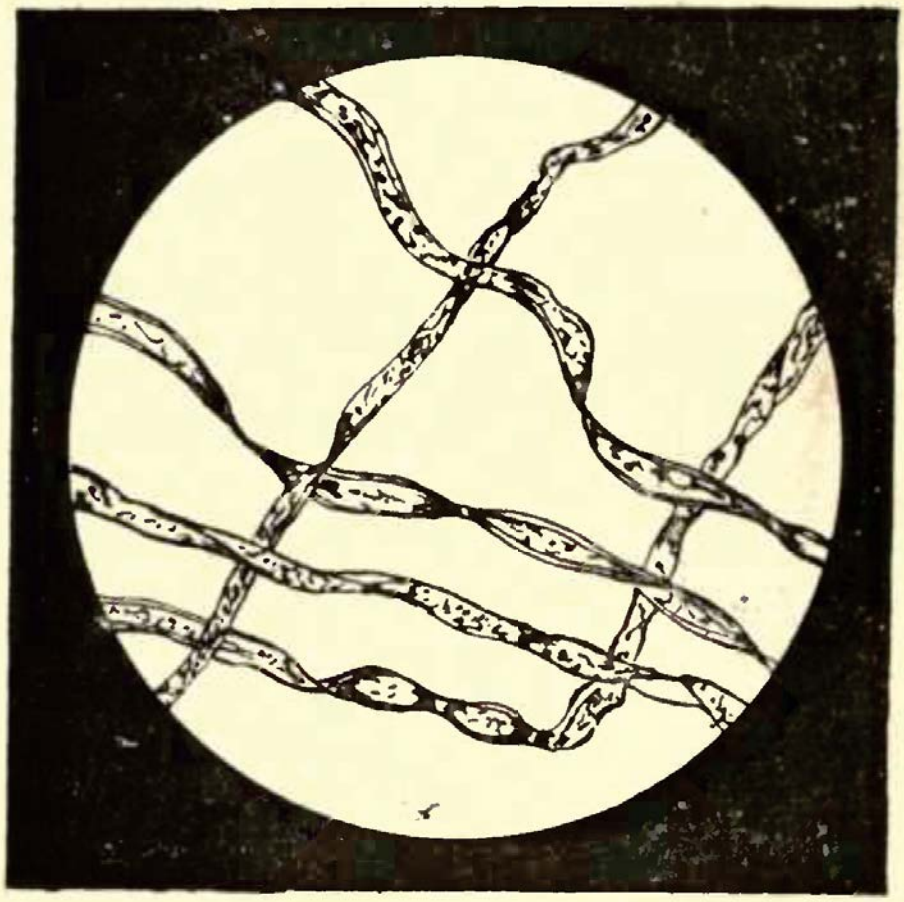

Fig. 28.

United States—Orleans.

superior in this respect to those of the white varieties of Egyptian cottons. The fibre walls are also much finer in their structure, and as regards the average diameter, I find that it is considerably smaller, although by almost all of the few writers who have

taken up the subject, it is stated to be greater than that of the white Egyptian fibres.

Texas.

35.—This variety belongs, like the Orleans cotton, to the Gossypium Hirsutum species, and has become, during the past few years, a rival to it for general commercial qualities and excellence. Nine or ten years ago this was, however, not the case, the Texas being then much inferior to the Orleans; but owing to many of the plantations in the former State having been taken over and opened up by experienced capitalists and planters from the cotton-growing centres of Georgia, Florida, Mississippi, etc., the development of the plant rapidly improved, and now ranks on a level with the finest of the American crops. The principal difference between the Orleans and Texas cottons lies in the colour, the latter being more highly tinted, or rather of a light golden hue, but in other respects they are possessed of properties and characteristics very similar in many respects. All deliveries of the medium and finer grades of this cotton are, in general, very free from leaf, seed, sand, and other foreign and impure matter, but they unfortunately contain either more or less unripe fibre. The lower grades are, however, often very dirty; and in many cases, of late years, large quantities of sand and water have been fraudulently added to the bales, with the object of increasing their weight. All Texas cottons are of fair strength, and can be used in the production of either twist or weft yarns, the counts of which are similar to those of the preceding variety.

Under the microscope the internal structure of the filaments of the Texas cotton appear to have much in common with those of the Orleans, but the fibre walls are slightly thicker and less pliable. The thickness of the tube walls seems to me, in some specimens, to be somewhat variable, and to vary in strength and elasticity.

Uplands.

This cotton, like the others of the American crop, is the product of the Gossypium Hirsutum species, and is largely cultivated on the inland plantations of America. It forms a very important division of our supplies of weft cotton, the strength being rather below the average, and the fibres soft, elastic, moist, and pliable. Each season's crops are generally very clean, and can, therefore, be worked with only a small percentage of waste being removed at the opener, scutcher, and other preparatory cleaning machines. Its colour is white, or of a light creamy tint, and it can therefore be used in the same mixing with many other varieties of cotton. By itself it is seldom reduced further than to 42 hanks to the pound, as the staple is too short and weak to admit of a finer yarn being extracted from it. It is now much prized and used by English and American spinners for weft yarns, as it makes a good round thread with a nice even surface.

Under the microscope the fibres of the Upland variety are shown to be rather inferior in the character of the natural twist, while the straight, flattened, ribbon-like filaments are also more numerous than in

the Orleans. This, no doubt, imparts to the cotton the softness it possesses, and accounts also for its lower standard of strength, the two chief characteristics which make it essentially a weft cotton. There appears to me also to be considerable variation in the position of development to which each individual filament has attained, or, in other words, there seems to be a large quantity of half and three-quarter ripe fibre distributed throughout the bulk.

Mobile.

36.—Of all the American cottons produced from the Gossypium Hirsutum species this variety is the most inferior, although it forms a considerable portion of the supply we receive from that country. It is, like the Upland cotton, employed largely in the production of weft yarns, being very similar to it in the strength of its filaments, while in colour it approaches to the Orleans varieties. It is, however, never so clean as either of them, containing a great percentage of foreign matter and undeveloped fibre which has been removed from the base of the seed in passing through the ginning machines. The lower grades are often sent to our markets heavily charged with broken leaf distributed throughout the bales, and sometimes containing excessive quantities of moisture.

These defects and impurities naturally reduce its working value considerably, and lessen the price which it could otherwise command in our markets. The spinning capabilities of the Mobile cottons, although on the average not so great as those of the

Fig. 29.

Upland (American) Cotton Fibres.

preceding variety, are, nevertheless, fairly satisfactory, that is, as we have already stated, for the production of weft yarns.

It can, of course, be, and is, mixed with other varieties, such as some descriptions of E. Indian, when the numbers can be varied accordingly.

Under the microscope one can see little difference in the fibres of this and the Upland variety. There appears, however, to be a considerable quantity of perfectly transparent tissue-like fibres, which represent the undergrowth of fine hair on the base of the seed.

Maceio.

A cotton produced from the native arborescent species—Gossypium Peruvianum. The fibres are characterised by the harshness common to all varieties of Peru cottons, and in other respects it is similar to the Ceara. The lower grades are sometimes very dirty, which make them relatively expensive to work. The counts of yarn for which it is adapted, and the lengths of the fibres, are much the same as in the Ceara.

Bahia, Aracaju and Paraiba.

The cottons are all the product of the Gossypium Peruvianum species, and are cultivated to a considerable extent on different parts of the eastern coast of Brazil. As they, however, possess no special peculiarities or qualities over the other Brazil varieties already described, but are similar in almost every respect, it will be unnecessary to enter into a repetition of the description there given.

Smyrna.

From Asiatic Turkey our markets receive a considerable quantity of cotton of the Gossypium Herbaceum species, the greater portion of which is raised on the western coast in and around Smyrna. As the plant, however, is also cultivated in the Greek Islands, and the crops are similar to those of Smyrna, they are generally classed and quoted together by Liverpool brokers. Some deliveries of these cottons are rather dirty, more especially in the lower grades, but on the

whole they may be termed as fairly clean. The colour is of a dull white, which, of course, does not improve their appearance, but, on the contrary, makes them look dirtier than what they really are. The fibres being only of a medium strength, they are better adapted for the composition of weft yarns.

West Indian.

37.—For many centuries the cotton plant has been cultivated to a considerable extent in several of the West Indian Islands, but more especially on those which are included in the British possessions. The climate is tropical, but modified by the daily sea breezes and by the elevations which are characteristic of most of the Islands. Barbadoes was long noted for producing the finest variety of cotton sent into our markets, and it was from this Island the Gossypium Barbadense species obtained its name, as it was supposed to be indigenous to the soil. From the seed of this species also, it is now generally supposed that the long-fibred cottons of Florida and Georgia were originally produced, as they resembled each other in many respects both in their external and internal structure. Almost all the cottons which are now produced on the different West Indian Islands are the product of an exotic species—Gossypium Peruvianum. They are generally possessed of a long staple, and, as regards the dry, harsh, wiry features, characteristic of the crops on the parent soil, they to a certain extent retain them. In point of cleanness, the cottons of this class are not so perfect as they might be if more atten-

tion were paid to them and to the careful picking of the crops, as all deliveries contain either more or less leaf, seed, sand, and immature fibre, which, of course, reduces the value.

Under microscopic examination of the fibres of this cotton, I was rather surprised to find that they possessed peculiarities not common to any other specimen of cotton, although, as far as I have been able to learn, nothing has as yet been said regarding them in any work on the subject of cotton. The fibres of this cotton I find to be not only uniformly twisted, almost without exception, from base to apex, and each indi-

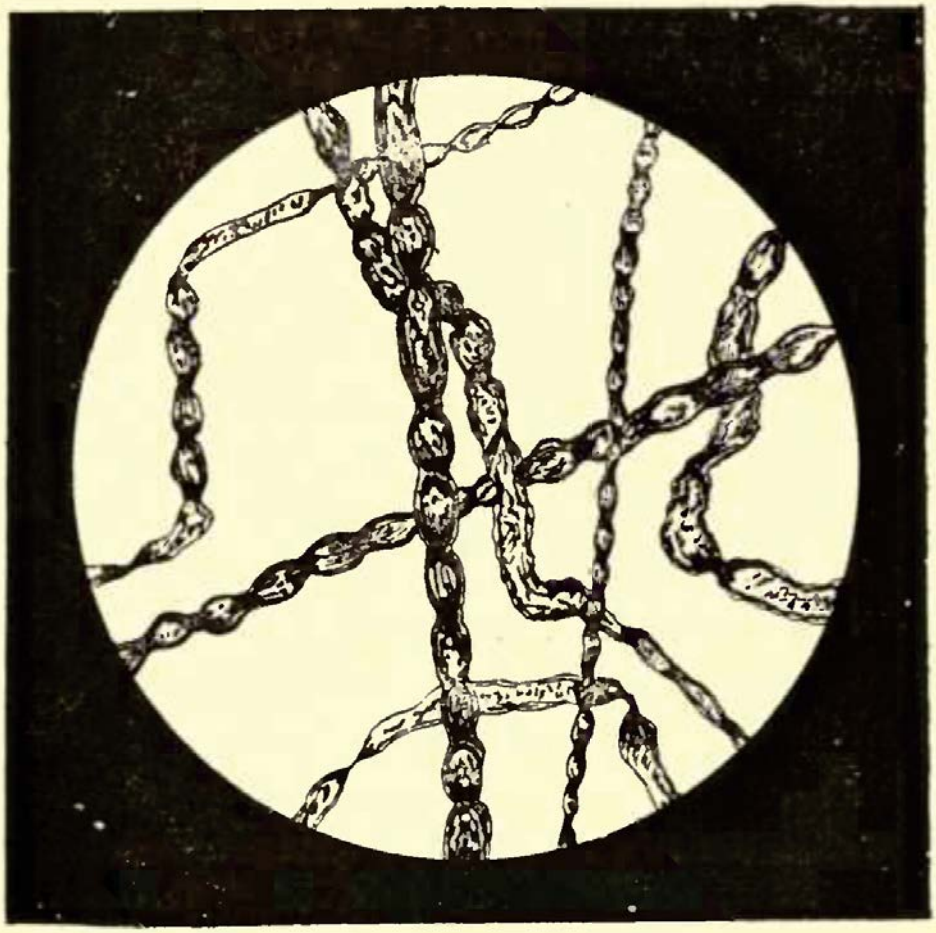

Fig. 30.

West Indian Cotton Fibres.

vidual twist is shorter and more cylindrical than in most other specimens of commercial cotton. In the former of these respects, this variety of fibre, has, I believe, no rival, not even in the Sea Island cottons, which have the nearest approach to perfection by the combination in the highest degree of the various natural phenomena which constitute a good fibre. To account then for the difference in strength, and comparative weakness of the West Indian cotton presents at first some difficulty, as a large amount of uniform twist has, as a general rule, been associated with strength. The West Indian fibres are, however, drier, consequently, more brittle and less elastic, and do not possess the peculiar adhesive tendency to one another in the same degree as exemplified in the Sea Island cottons.. In diameter, the fibres are rather irregular, as will be seen in our illustration, Fig. 30.

Santos.

This variety of cotton, although grown on the Brazil coast, is not a native of the country, but is the product of an exotic plant—Gossypium Hersutum, having been introduced from the United States plantations some few years ago. Although retaining many of the characteristics of the American cottons, yet it has largely partaken of the peculiarities of the Brazil varieties, being rather harsh and elastic in the fibre.

African.

38.—From various parts of Northern, Western, Central, and Southern Africa we draw a small portion

of our supply of commercial cottons, but the most prolific parts of this Continent are on the South-Eastern shores of Natal, and the Western coast of the State of Upper Guinea round Liberia. On many parts of the Eastern coast the soil is too barren for the cultivation of the plant, and in a district extending from the Sahara, across Arabia to the Persian Gulf, the great and continuous heat precludes agriculture in any form. The resources of Africa, in suitable soil and atmosphere, for the introduction and successful development of the cotton plant are nevertheless very large, but are only utilised to a very limited extent. As the country, however, becomes better opened up to commercial intercourse, and greater inducement can be offered to agriculturists and capitalists for the investment of their money and services, the area under cotton cultivation must necessarily increase to an extent which may in time be equal to, if not greater than, that of India. That portion of the country which at present produces the best variety of cotton as regards length, strength, and firmness of the fibres, is in and around the colony of Natal, where much greater care is bestowed on its cultivation and in the subsequent operations of picking and ginning. All African cottons are the product of the Gossypium Herbaceum species, a small shrubby plant indigenous to Asia and nearly all warm climates, and being of a hardier nature than either Gossypium Barbadense, Peruvianum, or Hirsutum, it can consequently be cultivated throughout a more extended latitude of soil and climate. If, however, the species of the plant is

not indigenous to Africa, it must have very early in the history of the art and manufacture of cotton been imported from India, where its cultivation can be traced back to prehistoric times In colour, the African cottons are of a clear, light golden tint, and very free from impure matter, such as broken leaf, seed,

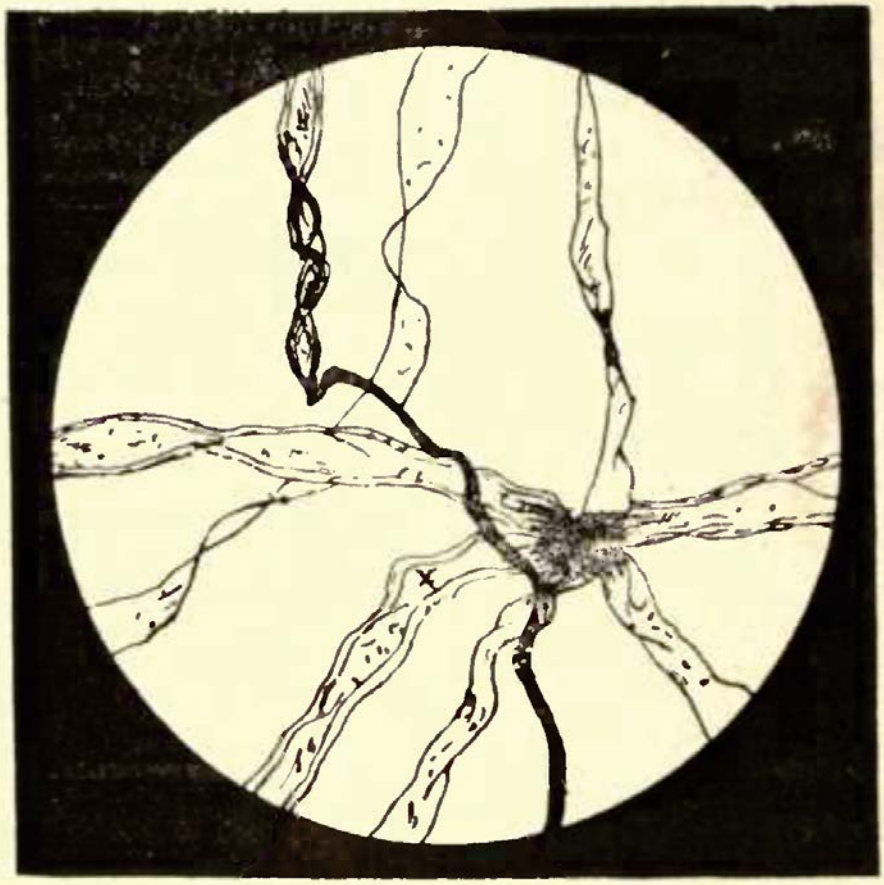

Fig. 31.

Microscopic Illustration of the African Fibre.

sand, etc. ; but, unfortunately, in every bale there is always a very great percentage of short down or fibre of about $\frac{3}{8}$ inch, or $\frac{1}{2}$ inch in length, contracted and curled up into small particles and adhering to the good fibre, making them appear as if in their surface they carried rough, warty excrescences. This defect

in some deliveries reduces the value of the cotton by about ¼d. per lb., and renders it a relatively wasteful material to work into yarn. In dealing with the presence and appearance of these short and defective fibres, it will be necessary to explain that in any country and district, or in any season when the heat has been very great and the rainfall or supply of moisture insufficient for the purpose of maturing and ripening the pods of the plant, that there is always a considerable percentage of the fibres on each seed becomes parched and deformed, and never attain to the length or strength of good commercial staple. On an average, the African cottons are fairly strong, but the crops vary much in this respect.

EAST INDIAN.

Hingunghat.

39.—From various parts of India we receive a variety of cottons, all of the native species—Gossypium Herbaceum, each of which is distinguished in our markets by the name of the district in which it was grown. The qualities and grades of Indian cotton are very numerous, corresponding to the diversity in soil and climate at different parts of the country, but, to place them on an average, they rank as inferior to any of those we have already described. The cause of this is not difficult to find. India lies between the parallels of 8 degrees and 37 degrees north latitude, so that, therefore, the greater part of the country is

within the tropics, and the heat very great. The rains depend upon the monsoons which blow alternately from the south-west and north-east, the former from May to October, and the latter from September. The south-west monsoon, passing in its course over a great expanse of water, generally carries abundant showers to the Malabar coast, but the north-east monsoon is comparatively dry. In a great portion of the Peninsula, therefore, little or no rain falls, and if removed at any great distance from the rivers or waterways, the soil is necessarily arid and dry, and not well adapted to vegetation of any kind. Excessive heat and deficiency of moisture are consequently the chief reasons why the cultivation of the cotton plant cannot be brought to the same perfection as in other countries. Some districts of India are, of course, better situated in these respects than others, the plantations in the vicinity of the hills having a milder temperature than those in the open country. The fields in the Berar province and those to the south of the plateau of Deccan are the most fruitful, and produce the best varieties of the Indian (Surat) cottons, and it is in this division that the Hingunghat is raised. The colour of this cotton varies slightly throughout the bulk, some parts being of a higher tint than others, in all probability owing to the crops of several planters being mixed and packed together, but taken as a whole it is much superior to any of the other Indian varieties. When compared to the American cottons, however, the Hingunghat appears inferior in point of cleanness, containing a considerable percentage of broken

leaf, seed, shell, large motes, sand, and other mineral matter, but when placed alongside several of the Brazilian species it can bear a favourable comparison in these respects. One important property that it possesses is strength, so that a good marketable yarn (when the material is properly cleaned) can be extracted from it. The counts or numbers for which it

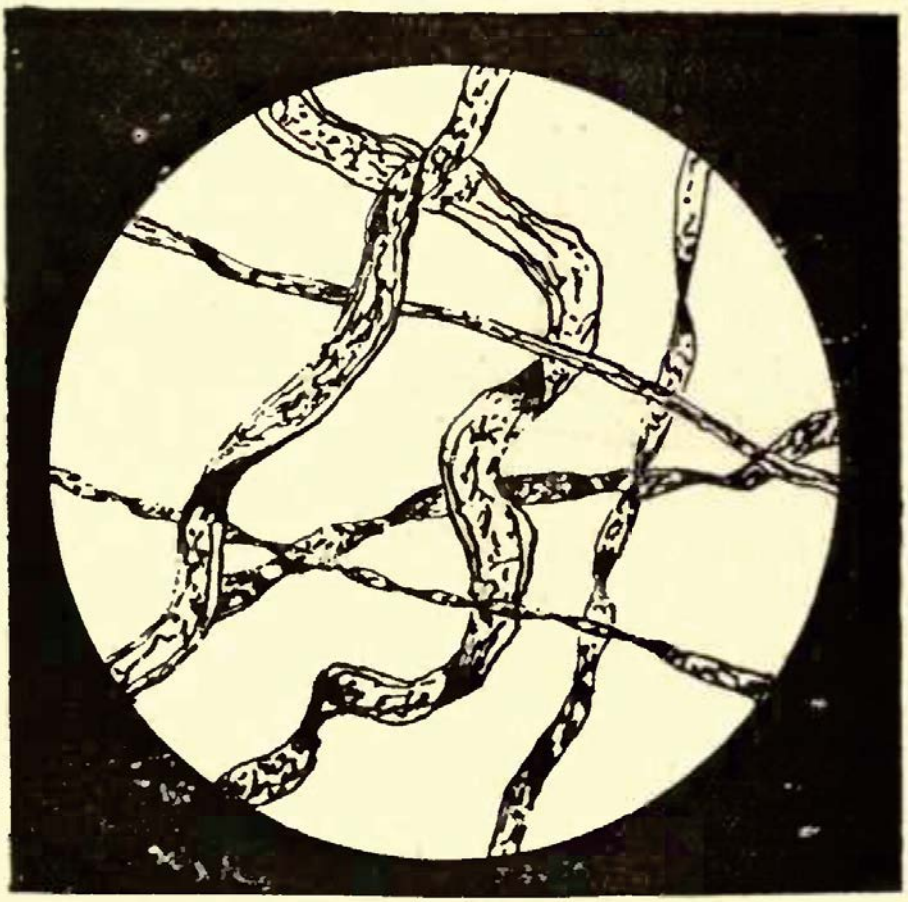

Fig. 32.

Hingunghat.

is best adapted range from 32 hanks to the pound downwards, but the finer grades may be reduced to 40's.

The secretive powers of the Hingunghat cotton must, when in active growth, be much greater than

the African, as the fibre walls are thicker and more perfectly developed. When using the micrometer glass, in the microscopical examination of this cotton, I was impressed with the variation that existed in the diameter.

Broach.

40.—The cottons to which this name is applied are the product of the Gossypium Herbaceum species, are cultivated to a considerable extent on the plantations of the Bombay Presidency, and rank next for quality and value to the Hingunghat in our markets. The Broach cottons are generally highly tinted, almost bordering on a golden colour, and fairly clean, although by the rough action of the ginning machines, which are usually worked to their utmost capacity, there is always more or less leaf broken up into very fine particles and distributed throughout the bulk. All grades of this cotton are also very subject to nep, caused both by natural and artificial agency, but as these form part of the subject by itself they will be dealt with under their proper heading.

Under microscopic examination the fibres of the Broach cottons appear to be much more regular in form and diameter than the Hingunghat, but the convolutions are much scarcer and not so clearly defined. The fibre walls are also thicker, and appear to me to be drier and more liable to rupture. Some few are also more cylindric than the average of those which compose the preceding variety, but they seem also more harsh and inflexible, and not so well adapted to constitute a good, strong, commercial yarn.

Tinnivelly.

Tinnivelly cotton is cultivated in the southern parts of the Presidency of Madras, where climatic influences are more temperate and equable than at any other part of the Presidency.

The chief external characteristics which distinguish the Tinnivelly cottons are, first, a dull creamy colour ; second, a high standard of strength ; and, third, an excess of elasticity. In general the crops are moderately clean when imported into this country, but some deliveries, of the middle and lower grades especially, contain much impure vegetable and mineral matter, broken into fine particles.

Fig. 33.

Represents the Fibres of the Cotton. Indian—Madras. (Tinnivelly).

Being fairly strong, it is well adapted for warp or throstle frame yarns. Our illustration, Fig. 33, represents the fibres of the Tinnivelly cotton. The general structure and appearance, it will be observed, is most peculiar, and different in many respects to any of those hitherto illustrated, while the tubular form is most conspicuously defined. Another feature of the Tinnivelly cottons is their deficiency in natural twist, none of them presenting the spiro-cylindric appearance characteristic of the West Indian, although many of them are partially twisted only.

Dharwar.

41.—This cotton ranks next to the Tinnivelly in value, each season's crops being in general fairly clean, although much of the staple is broken and ruptured by the action of the ginning machines. It is, like the Broach, the product of the Gossypium Herbaceum species, and is also cultivated in the Bombay Presidency. Under these circumstances, therefore, they have, as one would naturally suppose, much in common with each other, although in general qualities the latter is rather superior.

Under the microscope the internal structure of the two cottons is shown to be just as much alike as is their outward appearance, so that, therefore, the reader need only refer to the description given of the Broach cotton, as it equally applies to this variety.

Oomras.

The Oomrawuttee cotton includes several varieties, as will be seen in other parts of this work. Its chief

defect is dirtiness, many crops, when sent into our markets, being found to contain considerable percentages of leaf, seed, sand, shell, and other matter, so that there is always great waste in the working before a good, clean, marketable yarn can be produced from it. In other respects, however, it is fairly satisfactory, being strong and regular in the fibre and of a creamy colour.

Under the microscope the filaments of this variety will be observed to resemble in many points those of the Broach cottons. The perfectly spiral filaments are extremely scarce, but as a whole they approach more to a convoluted structure than either the Dharwar or Dhollerah cottons. The fibre walls are thick and dense, and some few appear very cylindric, but these seem also to be brittle and liable to get broken at any machine where the action upon them would be sudden or rough. The Oomrawuttee cottons are the product of the Gossypium Herbaceum species.

Dhollera.

Like the Broach and the Dharwar cottons, this variety belongs to the Gossypium Herbaceum species, and is also raised in the Bombay Presidency. It is, however, inferior in many respects to the latter, and in nearly every respect to the former of these varieties, each delivery containing large percentages of broken leaf, seed, and every other impurity common to cotton, while there is also always much unripe or partially developed fibre distributed throughout the bulk. The crops of different seasons and from different plan-

tations vary slightly in these respects, but if more care was exercised in their cultivation, and in the after-work of picking and ginning, a great improvement could be obtained and a higher price received for the cotton, as it could be manufactured into a better quality of yarn and with less waste in the working. The Dhollerah cottons are of a whitish colour, and the fibre is rather deficient in strength, so that it is best adapted for the composition of weft yarns.

In microscopic appearance the fibres of the Dhollera cottons possess no special peculiarities or characteristics, but partake of the general structure of the Surat cottons. They show less of the natural twist than the Oomrawuttee, but are similar in this respect to the Dharwar.

Westerns (Madras).

42.—Of the Madras cottons there are two kinds, viz., the Tinnivelly and the Western, the former being much more superior than the latter, and worth almost ½d. per pound more in our markets. This is chiefly owing to the soil in the western and central parts of the Presidency being not so well adapted for the cultivation of the cotton plant as at Tinnivelly. An important objection to this class of cotton is, that all deliveries are most exceedingly dirty, the percentage of leaf, seed, sand, shell, broken and ruptured and undeveloped fibre contained in them being exceedingly large. The fibres are, however, of a good standard of strength, and, but for the serious defect just mentioned, would otherwise be competent to produce a

good warp yarn. In colour it is of a somewhat deeper tint than Oomrawuttee, but in other respects slightly inferior to it.

Under the microscope the general appearance and structure of the filaments are shown to have much in common with the Tinnivelly cotton, already illustrated and described in detail.

Comptah.

Anyone who gives merely a glance at the cottons of this class cannot fail to be at once impressed with their most prominent feature, *i.e.*, dirtiness, for in this respect they far exceed any of those varieties we have already described. The impurities consist chiefly of broken leaf, seed, motes, etc., crushed up into very fine particles, and so plentiful are these particles, and so regularly distributed, that they give to the cotton a spotted appearance ; at least, one would suppose such to be the case if looking at it from any little distance.

The Comptah cottons are the product of the Gossypium Herbaceum species. The fibres are in general rather weak, and therefore best adapted for the production of weft yarns. In colour, the cottons of this class are of a brownish tint naturally, but this is heightened to some extent in appearance by the quantity of withered leaf which they contain.

Under the microscope the fibres show little difference to those of other Surat varieties, being dry and brittle looking, with thickly formed walls and few twists. To these characteristics, therefore, we may

attribute their deficiency in strength and the inferiority in the adhesive tendencies of the filaments.

Bengal.

43.—Of all cottons used for manufacture, this variety (with the exception of the one next described) is certainly most inferior and of the least value in commerce. Its fibres are among the shortest of the Indian cottons, and are mixed with every known impurity in all, but more especially in the lower, grades ; in fact, owing to the great percentage of broken leaf, seed, and sand which it contains, it is often difficult to determine the actual colour.

The best specimens are coarse, harsh, and wiry, and only used in the manufacture of the poorest description of domestic and other cloths. As regards the general inferiority in quality of this variety of cotton, natural agency has certainly much to do with it, but in the present system of raising and preparing the crop for market there is plenty of scope for improvement which, it is regrettable to know, is not being taken the advantage of that the importance of the matter demands. While the product of every other class of cotton has improved within the past fifteen or twenty years with respect to cleanness and working properties, the Bengal cotton has remained almost stationary, and from appearances is likely to continue so for some time to come.

Under the microscope the cause of the coarse and harsh appearance of the fibres of the Bengal cottons is made at once apparent. The thickness of the outer

walls is much above the average, as will be seen from an examination of Fig. 34, and it will also be observed that the general body is very dense. The twists, although not numerous, are large and well distributed, and, in conjunction with the two former

Fig. 34.
Bengal.

characteristics, impart to the fibres the strength which they possess. The Bengal cottons are the product of the Gossypium Herbaceum species of the plant.

Sind.

This variety of cotton stands almost on exactly the same level of commercial value as the Bengal,

although in length of staple it is slightly inferior. The Sind cottons are the product of the Gossypium Herbaceum species. The colour is of a dull white, and the fibres are comparatively strong, so that it can therefore be adapted to the production of a fair yarn of low counts.

The Indian Monsoons and the Crops.

As a rule the south-west monsoon strikes the Western Coast late in May, the rains reaching Bombay between the 5th and 15th of June, whereas the north-east monsoon rains usually begin at the end of September or early October off False Point, on the Coromandel Coast, reaching Madras about the middle of the latter month.

Crops Grown in the South-West Monsoon.

Hinghunghat (Central Provinces).
Oomras (Bombay, Berar, and Hyderabad).
Dhooleras (Bombay).
Broach (Bombay).
Sind (Sind).
Coomptas (Bombay).
Dharwars (Bombay).
Bengals (Punjab, North-West Provinces, Oudh, Rajputana, Central India, and Bengal).
Assam (Assam).

Crops Grown in the North-East Monsoon.

Westerns (Madras and Hyderabad).
Coconadas (Madras).
Tinnivellys (Madras).
Coimbatores or Salems (Madras).

CHAPTER IV.

General Natural Characteristics.

44.—With this variety we have now concluded a detailed description of the various cottons at present made applicable to the spinning of yarns. The reader will in all probability have observed that, as a general rule, the cottons which had the longest fibres were also the smallest in diameter, the silkiest in appearance, had proportionately the greatest strength, and were the most valuable ; and in their internal structure were more regular in diameter, appeared to have absorbed and retained the fluids of the plant, and to have the natural twist well developed and distributed.

The chief causes of strength in all cotton fibres seem to be (1) the presence of the oleaginous matter on the inner surface of the walls, deposited when the fibre was in active growth ; and (2) when the walls are of a certain thickness. Saline matter in the soil on which the plant is raised exercises a developing and strengthening influence on the product ; at least, such is the case in connection with the Sea Island cottons ; but good seed, a moist and alluvial soil, and a moderate and equable temperature are more necessary and important factors in the successful cultivation of the plant. Many good commercial specimens of the cottons which we have just described are grown in fresh water river valleys, and possess toughness, strength, and fineness in a very marked degree, so

that, although undoubtedly the plant has a predilection for the absorption of saline substance, yet the soil, seed, and climate exert a much more powerful influence.

All countries where the climate is very hot, and where moisture is deficient, produce a cotton irregular in the length of the staple, and of a dry, brittle, and weak nature. The cause of this is not hard to trace. The heat being intense, generates what I might call a forced vigour in the cellular deposit and formation of the fibre, so that before there has been sufficient time to admit of the thorough decomposition of the cell walls in contact, and allow the free and uninterrupted circulation of the ripening fluids in the tube, the pod bursts, and the cotton has then to be removed at once, or in its exposed condition it will get rapidly scorched and rendered useless for manufacture. In a similar manner, when water for irrigatory purposes is scarce, the tap root of the plant will not be able to absorb the quantity of moisture necessary for the perfect development of the capsules, consequently the fibres must necessarily be dry, harsh, and deficient in moisture and strength. In districts where the temperature is mild and equable, and the soil moist and loamy, the germination of the seed and growth of the plant proceeds gradually, each part becomes perfectly developed and matured ; and when the capsules are formed and the plexus of young fibre on the seed are in active growth, the oleaginous fluids are almost perfectly liquified and kept in constant circulation through the tube, leaving deposits on the inner surface, and thus regularly increasing the thickness of the walls and bringing the fibres to perfect maturity.

As regards impurities, it will have been observed that the most common defects in our supplies are chiefly broken leaf, seed, sand, etc., These are to a very great extent attributable to artificial agency, for if greater care was exercised in the cultivation and picking of the crop and preparing it for market, the percentage of this impure matter would become greatly reduced. In removing the cotton from the pods, we explained at the beginning of this work that the picker had to grasp the whole contents of the boll in one hand, and with a slight jerk thoroughly release and carry it off. As these labourers, however, are required to pick a certain quantity per hour, they are not over careful, and the result is that with the cotton they remove some of the withered leaf which surrounds the pod, and this getting broken up into fine particles by the saws or rollers of the ginning machine, it becomes distributed throughout the bulk, and reduces correspondingly the working qualities of the material.

45.—As a supplementary article to the detailed descriptions of the different varieties of commercial cottons, I have compiled the following tabulated statement. It will, no doubt, be found invaluable for ready reference, either as to the length of staple in different varieties, the counts and class of yarn for which they are best adapted, or their chief characteristics. Students preparing for the technological examinations should study it carefully, as it embraces very many points on which the examiners year by year base several of their questions :—

Commercial name of cotton.	Length of the fibres.			Extreme Variation.	Mean diameter of fibre.	Counts of Yarn.	Class of Yarn T.=twist, W.=weft.	Chief Characteristics.
	Max.	Min.	Mean.					
	in.	in.	in.	in.	in.			
Sea Island.....	$1\frac{15}{16}$	$1\frac{5}{8}$	$1\frac{13}{16}$	$\frac{5}{16}$	$\frac{1}{1700}$	120-300	T. & W.	Length and smallness in diameter of the fibres, silkiness, free from impurities, but contains some short and undeveloped fibre.
Florida	$1\frac{11}{16}$	$1\frac{5}{16}$	$1\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{1570}$	80-200	Do.	Ditto ditto ditto
Fiji Sea Island.....	2	$1\frac{9}{16}$	$1\frac{25}{32}$	$\frac{7}{16}$	$\frac{1}{1570}$	100-150	Do.	Similar to preceding varieties, but rather weaker, and containing larger per centages of unripe fibre.
Gallina	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{1480}$	70-120	Do.	Of a light golden colour, very strong, and much more easy to work into yarn than Sea Island.
Peruvian Sea Island...	$1\frac{3}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{1480}$	80-120	..	Neither so glossy, silky, or so fine as the Sea Island proper; of a light golden tint, and fibre moderately strong; some deliveries rather dirty.
Tahiti Sea Island.....	$1\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{1380}$	80-120	W.	Resembles in colour and appearance the Fiji Cotton, but contains greater per centages of "neppy" fibre; strength rather weak.
Brown Egyptian.....	$1\frac{1}{2}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{1380}$	50-80	T. & W.	Of a nice golden colour; strong, clean, and easy to work.
Rough Peruvian	$1\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{1380}$	40-70	T.	Of a light creamy colour, and feels harsh and wiry; remarkably clean, but in strength only moderate.
Smooth Peruvian.....	$1\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{1200}$	40-70	W.	Is soft, smooth, and pliable; resembles Orleans cotton in colour, and in other respects the "rough" variety.
White Egyptian.....	$1\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{1200}$	40-70	T. & W.	Contains more or less impure matter in the shape of broken leaf, &c.; colour of a light golden tint, and fibres fairly strong.

Commercial name of cotton.	Length of the fibres.			Extreme Variation.	Mean diameter of fibre.	Counts of Yarn.	Class of Yarn T.=twist, W.=weft.	Chief characteristics.
	Max.	Min.	Mean.					
	in.	in.	in.	in.	in.			
Pernambuco.....	$1\frac{7}{16}$	$1\frac{1}{8}$	$1\frac{9}{32}$	$\frac{5}{16}$	$\frac{1}{1200}$	40's-60	T.	Finest of the Brazil Crop, similar in colour to white Egyptian, but harsher and wirier in the staple.
Maranhams	$1\frac{3}{16}$	1	$1\frac{3}{32}$	$\frac{3}{16}$	$\frac{1}{1200}$	40's-50	T. & W.	Of a dull golden tint, and fibres not so strong as Pernambuco. Sometimes rather dirty.
Ceara	$1\frac{3}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	$\frac{1}{4}$	$\frac{1}{1200}$	40's-50	Do.	Fairly clean. Colour of a dull white, and of medium strength.
Orleans	$1\frac{1}{8}$	1	$1\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{1300}$	30's-50	Do.	Finest of American white cottons; generally clean, and economical to work. Fibres soft and moist, and of fair strength.
Texas	$1\frac{1}{8}$	$\frac{7}{8}$	1	$\frac{1}{4}$	$\frac{1}{1300}$	30's-50	Do.	Of a light golden tint; other characteristics similar to Orleans.
Upland	$1\frac{1}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{1}{4}$	$\frac{1}{1310}$	Up to 40's	W.	Very much like Orleans, but rather weaker in the strength of the fibre.
Mobile	1	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{1}{4}$	$\frac{1}{1310}$	Up to 32's	Do.	Never so clean as either Upland or Orleans, and not quite so strong.
Smyrna	$1\frac{3}{16}$	$\frac{7}{8}$	$1\frac{1}{32}$	$\frac{5}{16}$	$\frac{1}{1300}$	Up to 20's	Do.	Colour of a dull white; fairly clean, and fibres of a medium strength.
West Indian.....	$1\frac{3}{8}$	$1\frac{1}{16}$	1·23	$\frac{5}{16}$	$\frac{1}{1300}$	Up to 30's	T. & W.	Contains more or less impurities; moderate in strength, and fibres rather harsh and dry.
African	$1\frac{3}{16}$	$\frac{7}{8}$	1·03	$\frac{5}{16}$	$\frac{1}{1220}$	Up to 20's	T. (chiefly)	Of a clear, light, golden tint. All crops contain some per centage of very short fibres, but fairly free from other impurities. Fibres moderately strong.

Commercial name of cotton.	Length of the fibres.			Extreme variation.	Mean diameter of fibre.	Counts of Yarn.	Class of Yarn T.=twist, W.=weft.	Chief characteristics.
	Max.	Min.	Mean.					
	in.	in.	in.	in.	in.			
Hingunghat.....	1 1/8	7/8	1·03	5/16	1/1200	Up to 36's	T. (chiefly)	Of a light golden tint, and the fibres strong, often rather dirty. It is the finest variety of the Indian cottons.
Broach.....	1	11/16	·84	5/16	1/1200	Up to 28's	T. & W.	Of a high golden tint, fairly clean, fibres of a moderate strength.
Tinnivelly.....	1 1/16	11/16	7/8	3/8	1/1210	26's down	T.	Fairly strong, of a dull creamy colour and very elastic; moderately clean.
Dharwar.....	15/16	11/16	13/16	1/4	1/1210	Up to 20's	T. & W.	Fairly clean, much of the fibre sometimes broken; other characteristics similar to the Broach.
Oomrawuttee	1 1/16	3/4	·90	5/16	1/1180	Up to 20's	Do.	Always rather dirty, especially so in the lower grades. It is of a creamy colour and strong, and regular in the fibre.
Dhollerah	1 1/16	13/16	15/16	1/4	1/1180	Up to 20's	W.	Very dirty; of a whitish colour, and the fibres rather deficient in strength.
Madras (Western)...	1	3/4	7/8	1/4	1/1200	Up to 20's	T.	Exceedingly dirty and wasteful to work; of a deeper tint than Oomrawuttee, and fibres fairly strong.
Comptah.....	1	3/4	7/8	1/4	1/1180	Up to 15's	W.	Contains large quantities of leaf, etc., broken up into fine particles; of a brown tint, and fibres rather weak.
Bengal.....	1	3/4	7/8	1/4	1/1180	Up to 15's	T.	Very dirty. Fibres harsh but strong; colour of a golden tint.
Sind.....	7/8	1/2	·65	3/8	1/1190	Up to 12's	T. & W.	The poorest variety of commercial cottons. Fairly clean; colour of a dull white.

46.—Our microscopic illustration, Fig. 35, exhibits the thread of two different classes of yarn as taken from the cops—A being spun from white Egyptian and B from brown Egyptian cotton ; the fibres of the former having a mean diameter of $\frac{1}{1300}$th in., and the latter $\frac{1}{1500}$th part of an inch. Although both samples are of the same hank (No. 60's) it will be observed that

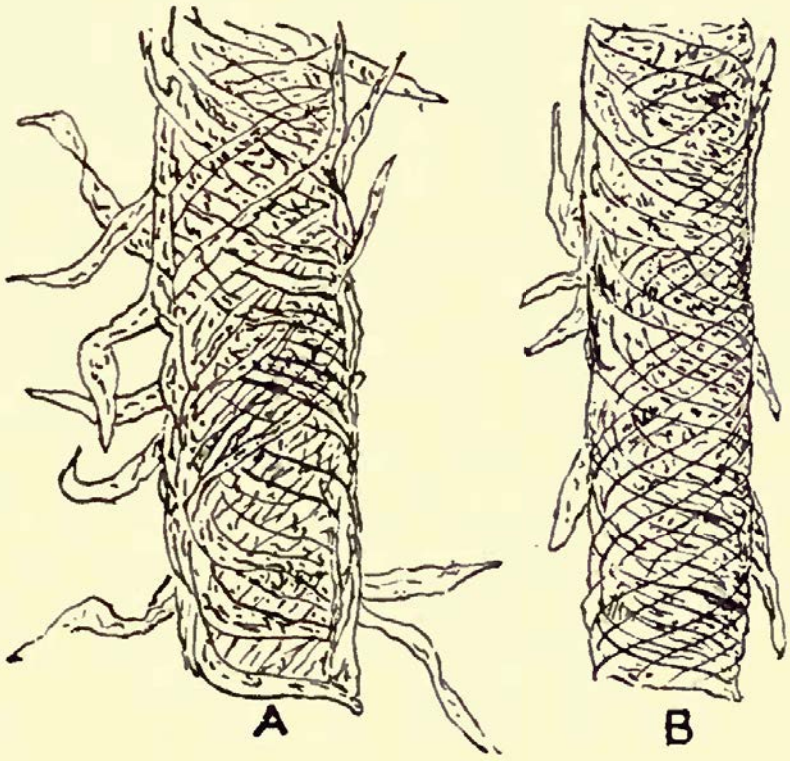

Fig. 35.

Showing microscopic illustration of the threads of two different classes of yarn taken from the cop. A being spun from White Egyptian, B Brown Egyptian Cotton.

the latter is much smaller in diameter than the former, has less loose fibre attached to it, and appears harder and better twisted. This is owing to the fibres of the brown cotton being finer than those of the white, consequently they lie close to one another, and retain in a more perfect manner the twist imparted to them

at the spinning mule or frame. From the same causes also the strength is materially increased, and the brown Egyptian cotton yarn can be adapted to weave a much finer variety of fabrics than the white. To test the difference in strength between these two classes of yarn I took six cops of each kind, and from these I wrapped one lea (120 yards) which I placed in the testing machine, with the following results :—

BROWN EGYPTIAN.		WHITE EGYPTIAN.	
Test.	Breaking Weight.	Test.	Breaking Weight.
No. 1	34 lbs.	No. 1	28 lbs.
„ 2	35 lbs.	„ 2	30 lbs.
„ 3	36 lbs.	„ 3	29 lbs.
„ 4	34 lbs.	„ 4	29 lbs.
„ 5	33 lbs.	„ 5	28 lbs.
„ 6	34 lbs.	„ 6	30 lbs.

From these tests, then, it will be observed that the average strength of the yarn spun from white Egyptian cotton is 29lbs., while the brown is 34·3lbs., or 18·3 per cent. stronger. In both cases the cottons were of good quality, and worked in such a manner as to constitute a high-class yarn.

SUNDRY NOTES RELATING TO COTTON.

Climate and Production.

47.—Cotton is grown over a large area of tropical and sub-tropical parts of the world, between 45 degrees north and 35 degrees south of the equator, and the characteristics of climate and production are therefore very varied. No doubt climatic conditions exer-

cise considerable influence on the yield per acre, but it is difficult to understand why the variation should be so great as :—

250 to 310lbs. per acre in Egypt.
200 to 250lbs. per acre in America.
50 to 90lbs. per acre in India.

The rainfall in the chief cotton-growing States of America during the months of June, July, and August average 10 inches, and the temperature from May to August inclusive varies from 75 F. to 81 F.

It is generally assumed that the proportion of fibre to seed cotton is as 1 : 3.

In India the temperature from May to September varies but little in the growing districts in a normal season, but the rainfall is erratic. Broach district averages 40 inches, Oomras 25 inches to 35 inches, Bengal 8 inches to 30 inches, Madras cottons 18 inches to 28 inches, for the four months.

It is worthy of note that the most uniform of the Indian cottons are grown in districts where the rain is plentiful and does not vary to any great extent.

In America the season's rainfall averages about 25 inches, and the yearly rainfall from 50 to 60 inches, more or less equally distributed over the twelve months of the year.

In India the rainfall in the Bombay district is confined to the period between June and October, and for the remainder of the year no rain falls. Thus, in the season the rainfall is :—

America, about 25 inches ; Broach, 40 inches.

While for the year it is :—

America, about 55 inches ; Broach, 40 inches.

This better distribution of the rainfall throughout the year in America prevents the ground becoming hard and dry, renders it more easily amenable to cultivation, and allows the tap roots of the plants to penetrate further into the soil.

In Brazil the rainfall is heavy, and in Egypt the irrigation depends largely on the overflow of the Nile.

In growing, the plant requires a humid atmosphere to develop its bolls (and, therefore, also its fibres) to the fullest extent, and the district which has a steady and uniform rainfall within certain limits possesses this natural aid to cultivation.

Cultivation of Ground.

48.—It is well known amongst agriculturists that if the same class of crop is produced year after year in the same ground the nutritious powers of the soil are rapidly reduced. All soil must contain certain constituents, according to its situation, and every plant has special partialities for one particular constituent, so that before this becomes exhausted, a different crop should be substituted to allow time for the previous constituent to be replaced. A rotation of crops, with the judicious use of fertilisers, will always be found to pay in the end. Ground exhausted by a succession of years of cotton growing can, it is said, by a year's growth of cow pea be restored to fertility. The late Sir B. A. Dobson gives the cycle of rotation best adapted as cotton, cow pea, corn, and grass, and this opinion is one which is general in America.

In India this part of the subject is to a very great extent neglected, and Indian cotton will be limited in its range of quality until some practical efforts are made to establish a rotation of crops best suited to the character of the soil.

Half-pressed and Full-pressed Bales.

In England the half-pressed bale has been superseded by the full-pressed bale, and therefore little opportunity has been given for a study of the comparative results of the cottons in working. It is generally assumed by spinners and authors that the spinning quality of the fibres are not affected by heavy pressing, and the subject has formed at least one question in the examinations of the City and Guilds of London Institute. To settle this question I have made careful experiments in India, and although anticipating a difference in favour of the half-pressed bales, I was not prepared to find it was so great. The strengths given are from one lea of yarn, and in each case represents the average of three cops.

From Full Pressed Bales.	From Half Pressed Bales.
61·4 lbs.	66·0 lbs.
51·7 lbs.	54·0 lbs.
68·0 lbs.	73·0 lbs.

These figures show about 7 per cent. difference in favour of the loosely packed cotton, and the advantages of the latter are further borne out by the preference shown in India by mill managers for the soft bales.

In India the half-pressed bale is called a *dhokra*. A *buffla* is a smaller bale of the same type.

A full-pressed Indian bale containing about 420lbs. of cotton will measure 10 cubic feet, while a half-pressed bale containing about 500 lbs. of cotton will measure 50 to 60 cubic feet, or about five times the measurement.

Selecting Cotton.

49.—The buyer of cotton ought to be a man of long and varied experience, not only theoretically, but in its practical manipulation. Under ordinary circumstances, therefore, the intelligent, careful, and conscientious mill manager is the right and proper person for the post. If conscientious, his own personal interest lies in getting the cotton most suitable for his purpose at the lowest price, as the results will show in the working of his mill, and in the reputation which he must realise accordingly. The operation seems simple enough. General cleanness seems obvious, but this is not all. I have seen two samples of cotton look equally dirty, but in the one case the impurities were such that they were capable of being removed without much damage to the fibres, whereas with the other there would have been considerable loss. The worst impurity is nep, the next irregular fibres, then leaf, seed, and lastly sand. In an examination of samples of cotton the presence of these impurities should be carefully considered, and when that is done, it is time to decide about length and strength. Everyone is familiar with the rough and ready test of pulling out

and breaking between the fingers, and in the hands of an expert a very accurate decision can be arrived at.

When the cotton is delivered in the bale, it should correspond to the characteristics of the samples, and if it does so, then the last test should be applied, that of determining the moisture which it contains. This can be done by placing any accurately weighed quantity of loose cotton in an oven and subjected to radiated heat at about 180 degrees to 200 degrees F. for an hour or more. If the weight taken was, say 24ozs., it should weigh when taken out about 22oz., or, say 8 per cent. Anything over this can be taken as artificially added moisture. These remarks apply to England and countries of similar climate, but in tropical countries in the dry season the evaporation is only about 5 per cent.

Twist and Weft Cottons.

The discrimination given to the selection of twist and weft cottons is not developed as fully as it might be. In many cases, with more or less reason, the two yarns are produced from the same mixing, and it is only in mills where large quantities of both yarns are being turned out that the question receives any consideration.

There are some cottons so very soft and weak that it would be impossible to spin yarn of any warp strength from them, whereas, on the other hand, some are so harsh and wiry that the production of weft yarn would be most unsatisfactory. Between these extremes

the knowledge and carefulness of the selector come into play, the price, the appearance, and the quality of the yarn depending to some considerable extent on the result. The characteristics which should be necessary for weft cotton are :—

Softness, ooziness, and moderate strength, but a weak cotton must necessarily be a weft cotton.

For twist, the cotton should be strong, elastic, and pliable, but a harsh, wiry cotton must in any case be a twist cotton.

In most cases the mixing for twist can be made less expensive than that for weft, as hard cottons are generally less expensive than those that are open and soft.

Cottons Required for Special Purposes.

50.—America (United States) produces two varieties of cotton of exceptional quality which are used for special purposes. These are :—

Benders and Peelers.

They are the product of carefully selected seed grown in the best soil in Mississippi, etc., and with the greatest care.

Benders cotton has long, fine, and strong fibres, but frequently dirty. Peelers cotton is also long, fine, and silky and very white, and is chiefly used in the manufacture of velvet.

Hosiery yarns :—Brazilian and Peruvian cottons make good white hosiery yarns. Brown Egyptian makes a good reddish hosiery yarn.

Flannelette yarns :—Dhollerah, Mobile, and American cotton waste can be used for yarns to produce raised goods of this class.

Class of Cloth.	Counts of Warp.	Counts of Weft.	Class of Cotton.
Shirtings	Low and Medium Counts	Low and Medium Counts	I. & A.
Dhoties	do.	do.	do.
Domestic	18—24	16—40	do.
Sheetings	12—20	12—20	I. & W.
Mexicans	18—20	20—30	A.
Printers	32	50	A. & E.
Jacconett	32	50	do.
Mulls	60—90	60—100	E. & S I.
Cambrics	80 upwards	80 upwards	S. I.
Sateens	32—70	36—80	A. & E.
Velveteens	50 to 100	60 to 120	E. & A.

I.—Indian. A.—American. E.—Egyptian. S.I.—Sea Island. W.—Waste.

Velvets :—White Egyptian cottons are used in the manufacture of yarns for velvets. So also is Peelers cotton and Brown Egyptian.

Mercerising :—Brown Egyptian cotton is one of the best for mercerising purposes, that is, for receiving a lustre by chemical means, rendering it like silk in appearance.

Lace :—Egyptian cotton and Sea Island cottons are generally used.

Sewing thread :—The best Egyptian cotton and also Sea Island are used for this manufacture.

Coconada and Naukeen cottons :—These cottons (and also the red Peruvian) are of a very dark colour—

a yellowish red. Coconada is an Indian cotton suitable for, say, 10's to 12's, and Naukeen is a China cotton, suitable for yarns up to 20's counts, where the colour is suitable.

Enemies of the Cotton Plant.

51.—The most frequent recurring enemies to the cotton crop are :—

In America..... Frost.
In India..... Drought.

In the latter country, drought is invariably accompanied by high atmospheric temperatures, which almost entirely ruin the crops. Excessively wet seasons are rare, but in other growing countries they are experienced from time to time with disastrous results.

Frosts, especially during the early stages of growth, have been frequently responsible for the destruction of large areas of cultivation in America, and so also has abnormally high temperatures, the loss having been as high as 300,000 bales. In an earlier part of this work climatic influences on the growth of the cotton plant have been referred to at length, but the animate enemies of successful cultivation have to be considered. These are :—

The cotton caterpillar (alethia argillacea), order Lepidoptera, family Heterocera, class noctnidae.

Boll caterpillar, and several others.

The familiar names in America for the dangerously destructive and rapacious enemies are the *cotton louse*

(attacks the young shoots), the *cut worm* (destroys the plant when young at the bottom), the *boll worm* (eats through the boll, and destroys the cotton), the *army worm* (so called because they travel together in countless numbers, completely denuding the plants of leaves, and sometimes destroying the bolls), and the *caterpillar worms* of the cotton moth, which are produced in such abundance as to be able in a few days to devour the leaves of every plant to which they attach themselves. Numerous and varied attempts have been made to discover ways and means of exterminating the pests, but none have been quite successful. The cotton caterpillar has its four stages of life, like any other moth, viz., egg, caterpillar (larva), chrysalis (pupa), and the moth (imago), and it is at the caterpillar stage where the most successful attempts of artificial destruction of the pests have been made. For this purpose, Paris Green or arsenic and red lead are used, being applied either by sprinkling or spraying. All birds, fowls, and many animals and insects are the greatest help of the cotton grower in the work of protecting the cotton plants from the attacks of the caterpillar, and it is quite safe to assert that without these natural allies, man's efforts in arresting or lessening the destruction would be of little avail.

The following description of the Cotton Boll Weevil was lately given by the author to the *Indian Electrical, Mechanical, and Textile News*, published at Bombay :—

The Cotton Boll Weevil.

The excitement in America at present regarding this destructive pest is not without cause. It is one of the worst enemies of the cotton plant, and once it settles on a plantation the agriculturalist is helpless to prevent the annihilation of his crops. It first showed itself in Mexico, and is then supposed to have spread to different districts by the transmission of kuppas, or seed cotton for ginning purposes.

Texas is now the chief seat of its operations, and even in the face of every precaution and the use of destroyers which are effectual with other pests, the weevil is rapidly increasing the extent of its destructive work. Its extirmination is at the present moment one of the chief topics of study among those connected with cotton and agriculture, and Governor Lantam, of Texas, has offered a prize of 50,000 dollars (Rs. 1,50,000) to the inventor of any successful system for destroying or stopping the ravages of this comparatively new enemy of the cotton plant. The amount is to be paid out of the State Treasury.

The weevil is of a brownish colour and about a quarter of an inch in length.

In Mexico its destructive visits were so great that for many years cotton growing was entirely discontinued in one district, but so long as it confined itself to a limited area no very general notice was taken of its existence. It has now travelled northwards, but there is no reason to suppose that it will not find its way to the Northern States and even to the other cotton growing countries.

The weevils secrete their eggs in the buds and young bolls ; and when the larvæ are hatched they feed on the interior. By the time the larvæ reach maturity they pupate in the recess which has formed within the inside covering of the boll and then eat their way out through a small hole, leaving any number from five to a dozen larvæ in the hole.

The weevils are not known to feed on anything except the cotton bud and boll, and never touch the leaves, so that it is almost impossible to detect their presence until the work of destruction has been done. They seem to be in active existence during the whole of the growing season, but how they come and go is not yet known. The first intimation of their presence

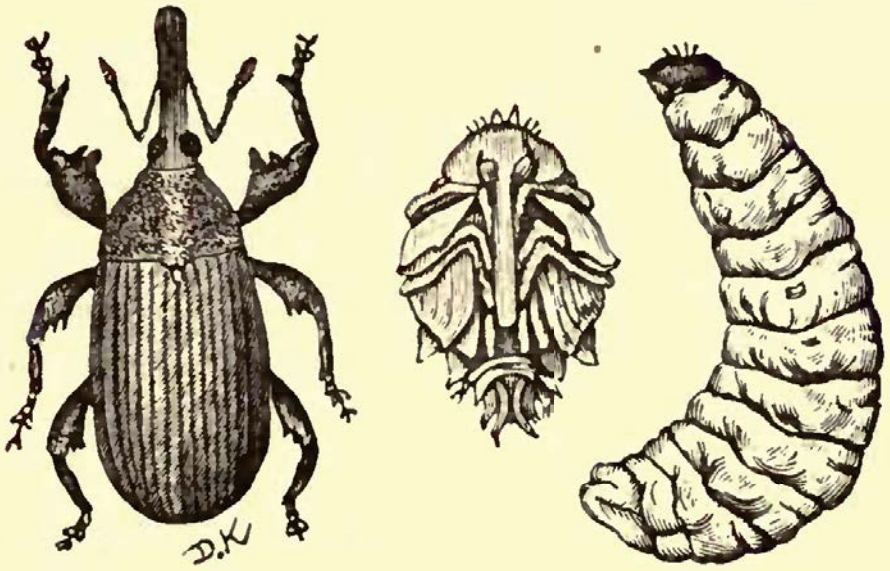

Fig. 36.

The Cotton Boll Weevil, in its Three Stages of Development.

is the falling off of the flowers, or the bolls drying up, or being retarded in development.

Many methods for extirmination have been adopted, but without any success. The ordinary

cotton pest carries on its operations on the outside of some part of the plant, and can, therefore, be generally reached by insecticides, but with the weevil this is not possible.

The piercing of bolls by insects means their destruction, and the attack is not confined only to the weevil. There are others which operate in this direction, but as they only act from the outside, they can, to a certain extent, be dealt with as already described.

Waste Made by Different Cottons.

52.—The percentage of waste made in converting cotton into yarn varies with every variety, and in every mill the following are fair averages :—

Sea Island (with Combing).—

Loss at Scutchers	5 to 6	per cent.
„ Carding Engine	4 to 5	„
„ Combing Machine... ...	12 to 20	„
„ Succeeding Machines ...	4 to 6	„
	25 to 37	„

Egyptian.—

Loss at Scutchers	5½ to 6	per cent.
„ Carding Engine	4½ to 5	„
„ Succeeding Machines ...	3½ to 4½	„
	13½ to 15½	„

American.—

Loss at Scutchers	7 to 7½	per cent.
„ Carding Engine	4½ to 5	„
„ Succeeding Machines ...	4½ to 5	„
	16 to 17½	„

EAST INDIAN.—

Loss at Scutchers	9 to 10	per cent.
„ Carding Engine	4½ to 5	„
„ Succeeding Machines ...	4½ to 5½	„
	18 to 20½	„

MIXING OF COTTON.

53.—It has been pointed out in various parts of this book that cottons sent into the market vary considerably, and the variations can be summarised as follows :—

(1) Length of fibres.
(2) Diameter of fibres.
(3) Strength of fibres.
(4) Softness of fibres.
(5) Elasticity of fibres.
(6) Colour of fibres.
(7) Uniformity in these respects.
(8) Cleanness.

Not only do cottons from different districts vary in these respects, but cottons from the same district (for reasons already explained) differ at times in many important particulars. A difference in the character of a season will show itself in the character of the cotton, and, as has been pointed out, cotton fibres from the same seed are not all alike. The process of mixing cotton, which appears a simple one, becomes much more complex when these points are fully taken into consideration. The results which depend upon the quality of the mixing are :—

(1) The strength of the yarn.
(2) The uniformity of the yarn.
(3) The cleanness of the yarn.
(4) The general appearance of the yarn.
(5) The amount of waste.
(6) The cost of the yarn, and
(7) (All other conditions being satisfactory) THE SUCCESS OF THE MILL.

In mixings, the following combinations should be carefully avoided, and the paragraph might fittingly be headed :—

DON'T.

(1) Don't mix long and short fibres together.
(2) Don't mix soft and harsh fibres together.
(3) Don't mix strong and weak fibres together.
(4) Don't mix dry and moist fibres together.
(5) Don't mix dirty and clean cottons together.
(6) Don't mix cottons of different colours together.

Re No. 1 :—Long and short fibres, if mixed together, result in an irregular yarn, which shows an absence of that smoothness and roundness which are so necessary. In addition, much of the short fibre is thrown out in the form of flat, clearer, and other waste, while some quantities entwine themselves erratically round the long fibres, giving a hairy, loose appearance to the yarn.

Re No. 2 :—Soft and hard fibres do not make a good combination. Soft fibres better adapt themselves to twisting than hard fibres, therefore in diameter and stiffness the yarn must vary. As a general rule, also, soft fibres are weaker than the

harder ones, and a yarn showing variations in strength tests must naturally follow.

Re No. 3 :—Other characteristics being alike, strong and weak fibres could be spun together if uniformly and accurately distributed throughout the bulk. It is obvious, however, that this is impossible, and this combination would, therefore, result in variations in test strengths, and softness in the yarn.

Re No. 4 :—Practical experience has shown that it is not desirable to combine dry and moist cottons, and in many cases the mixing of old and new season's cotton is not to be recommended for this reason alone. The dry cotton is lighter than the other, more easily opened and cleaned, while a cotton in a fully natural moist condition is more pliable, and to a certain extent stronger.

Re No. 5 :—For two reasons the mixing of dirty and clean cotton is not desirable. (*a*) Some of the impurities from the former pass into the latter, (*b*) the dirty cotton should receive more cleaning, or a different system of cleaning to the other. It is obvious that if they both get the same amount of beating, the dirty cotton will either receive too little, or the clean cotton too much.

Re No. 6 :—Cottons of different colours should not be mixed together, as the resulting yarn shows a dull, irregular tint, and a want of clearness which is required in all good yarn. Thus, the following, amongst others, should not be mixed together :—

Brown Egyptian and Brazilian.
Broach and Uplands.

Brown Egyptian and Orleans.
Texas and Dhollera.

54.—The selection of cottons and their mixing together is a post, therefore, requiring much care and experience to obtain the best results. In cotton-growing and manufacturing countries such as America and India, the difficulties of selection are increased, as the sub-divisions of each variety are much more numerous than in England, and a much more extended knowledge is therefore required by the buyer. For example, in many Indian mills a mixing may be made up of cottons received from seven to nine different districts, and the niceties of selection and proportioning can therefore be realised. In England it is very seldom that more than three varieties are blended together, but each of these may be the product of several districts, with the selections of which the consumer has nothing to do. In a combined growing and manufacturing country the product of any particular district can generally be obtained by the manufacturer, so that in this respect his possibilities of obtaining uniform yarn are greater than those of his competitors in a country which is a consuming one only.

It is greatly to be regretted that the finer details which should be associated with the mixing of cotton are to a large extent neglected. In England this is particularly the case, and till more importance is attached, not only to the selection of the cotton, but also the actual mixing of it, a leakage of a considerable amount of invisible profit will always exist.

Here is a comparison from actual working which will clearly prove this point. Two mills in Bombay were producing the same counts of yarn, and the selling price fluctuated very little between them, but never long in the favour of either. Practically speaking, therefore, their yarns were of the same market value. After considerable difficulty the following particulars were obtained :—

(1.) There was little difference between the quantities of waste made in the mill.

(2.) One of the mills was using a mixing made up of four grades of cotton averaging Rs.147 per candy (784lbs.), while the other was using one or two* averaging Rs.150 per candy. On the consumption the difference in cost amounted to Rs.18,000 for the year, or equivalent to three per cent. on the capital of the mill.

This is a very mild example, as the differences must in many cases be considerably greater than the above, but the particulars given were carefully verified, and related to two mills, both of which were excellently managed.

Mixings should always be made as large as the circumstances will permit, as this tends to uniformity in the yarn. These are :—

(1.) Space area available in the mixing room.

(2.) Class and counts of yarn to be produced.

(3.) The season.

(4.) The characteristics of the cotton.

---

* May have been three.

(5.) Finances of the concern.

(6.) The productive capacity of the mill.

Whether the mixing is to be made from several varieties, or only from one variety, the modus operandi is the same. The *bing* (or mixing) is built up of separate layers, each layer representing the cotton of a certain number of one class of bales.

When the mixing has in this manner been completed, the cotton when required should be drawn downwards, or, in other words, a vertical slice should be taken for the heap, either by the hand of the operative or by means of a rake, as in this way part of each bale is removed at the same time, and so that any irregularity which might have existed in one or two of the bales, by being distributed over a much greater body of the cotton, its otherwise hurtful influence becomes almost entirely neutralised. In many concerns two different classes of cotton are used together in the one mixing, and where such is the case the best plan to adopt is to make the bottom layer entirely of one kind, the next layer of the other, and so on, every alternate layer being composed of the same class. Another system in vogue at some cotton mills is to make separate mixings, and only blend them together at the scutcher after the material has been made into laps.

The Cotton Buyer or Selector.

55.—The manager of the mill, provided he possesses this knowledge, should be the buyer, as it is only reasonable to suppose that he, being directly responsible for the working of the material, the quality

of the yarn, and the ultimate success of the concern, will have the greatest interest in obtaining the cotton of the best quality that the price which he can offer will allow. There are, no doubt, numerous instances where the manager is not sufficiently informed in this respect; but where such is the case the substitute should be understood to be a man of the strictest integrity, and possess a practical knowledge of the working of different classes of cotton.

In the outside commercial transactions of a cotton mill, the buying of cotton is by far the most important, and requires a discriminative power which can only be gained by long experience and study of the peculiarities which characterise the different varieties of the cotton plant product. Successful cotton buying is as essential to the success of a concern as good and economical management.

Cheap Mixings.

Practically, the object of mixing different cottons together is to make the cost of the cotton as low as possible. Like everything else, it is at times carried to excess, and always with disastrous results. With a poor mixing it is impossible to make a good yarn, and the attendant consequences in the working are :—

(1.) Increase in waste.
(2.) Loss in production.
(3.) More labour in keeping the machinery clean.
(4.) Loss in wages to the workpeople, and more work.
(5.) General discontent throughout the mill.

(6.) The mark of the mill gets a bad name in the market.

In these respects the responsibilities of the cotton selector are very great, and can only be fully appreciated by those directly interested. The competition in the cotton trade has made the margin between the cost of the material and the yarn so small, that no means of increasing it should be neglected. Unfortunately, however, the directors, managers, or agents, when confronted with the difficulty of making both ends meet, are ever ready to look to the mixing room for the means of salvation, without fully going into the question of economies in other directions. When once the yarn shows signs of depreciation in quality or price, an exhaustive study of the working of every department should be made, and if this fails to account for the change, then the quality of the mixing should be improved. Managers and overlookers are frequently unreasonably blamed when the quality of the yarn falls off, or shows an unaccountable decline in price, when perhaps an inferior mixing has been supplied to them. On the other hand, some of them are ever ready to blame the mixing for defects in the yarn or insufficient production, when perhaps the supervision exercised has not been all that it might have been. An expensive mixing is costly, but one of a quality insufficiently good to produce the class of yarn required is infinitely more expensive in the end.

No two managers agree on the composition of mixings, even when the other conditions are almost exactly similar, and in any case it would be impossible

to lay down anything like a hard and fast rule. The following are mixings in use giving satisfactory results :—

10's (Ordinary).

	Per cent.
Bengal	50
Oomras (Khandeish)	20
Card and other waste	30

10's (Ordinary).

Oomras	40
Bengal	20
Waste	40

20's (Good).

Broach	50
Compta	15
Oomras	20
Dholleras	15

30's (Ordinary).

Barsee	50
Dholleras...	50

10's (Good).

	Per cent.
Oomras	40
Compta	20
Dholleras	20
Waste	20

20's (Fair).

Broach	30
Dholleras	30
Oomras	40

20's (Good).

Dholleras	40
Dharwar	25
Barsee	35

30's (Good).

Barsee	40
Broach	30
Compta	30

30's (Good).

Broach	75 per cent.
Surat...	15 „
Dholleras	10 „

56.—It will be observed that the foregoing mixings only include Indian cottons. The waste referred to in the 10's mixings consist of :—

Card drawing and rove ends ..... 15 per cent.
Clean dropping, fly, etc..... 15 per cent.

Of the waste put into a mixing the relative proportions to the total are about, strips 50 per cent., fly 30 per cent., droppings 20 per cent., for ordinary 10's.

When waste is to form part of a mixing, the proportion used must be kept within narrow limits. This proportion depends upon :—

(1.) The class of waste,
(2.) The cleanness,
(3.) The quality of the cotton with which it is to be mixed, and
(4.) The counts and class of yarn to be spun.

The waste should be distributed in small and uniform quantities at regular intervals, as, in this way, the evil effects which must necessarily arise from its use are minimised.

The following mixings are also made :—

16's (Good).
Good Dholleras and
Dharwars.
28's Weft (Good).
Broach.
32's to 40's Twist (Good).
Hingunghat or Texas.
32's Weft (Good).
Uplands.
50's Twist.
White Egyptian
60 per cent.

Brazilian 40 per cent.
80's Warp (Fairly good).
Brown Egyptian.
28's Twist.
Texas 60 per cent.
Hinghunghat 40 per cent.
28's Weft (Cheap).
Mobile 66 per cent.
Dholleras 34 per cent.
32's to 40's Twist (White).
Orleans.
High-class 40's.

Brown Egyptian. 60's Twist. White Egyptian 75 per cent.	Brazilian 25 per cent. 80's Extra Good. Sea Island.

100's Upwards.
Sea Island.

Uplands and Dholleras have been used in the proportion of 3 to 1 in producing a fair 30's weft yarn, while white Egyptian and some of the Brazilian varieties make good 40's to 50's.

In Egyptian cotton spinning, waste is seldom used except lap ends and slivers from the cards, combers, and drawing frames.

In the better classes of yarns from American cottons, the wastes added are lap ends, card, and drawing sliver, and slubbing and intermediate bobbin waste.

When through certain circumstances it becomes necessary to mix hard and soft, brownish and whitish, or long and short fibres together, the best system is to make separate mixings of each variety, and pass them separately through the machines up to the finisher scutcher. Here, two laps of each (or whatever proportion is required) can be fed through together. In this way the fibres are more uniformly distributed when they reach the carding engine than they would otherwise be, and the discriminating action of the preceding machines is avoided.

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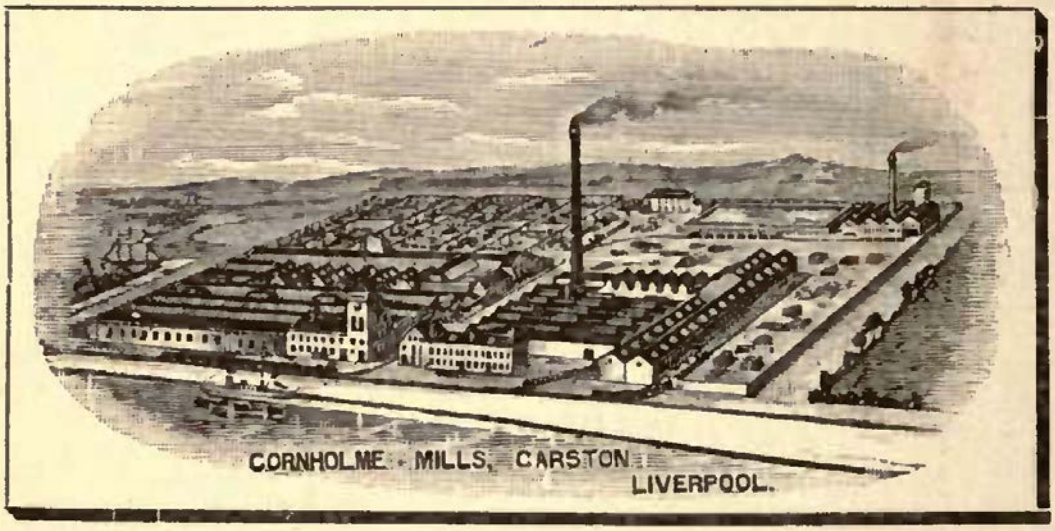

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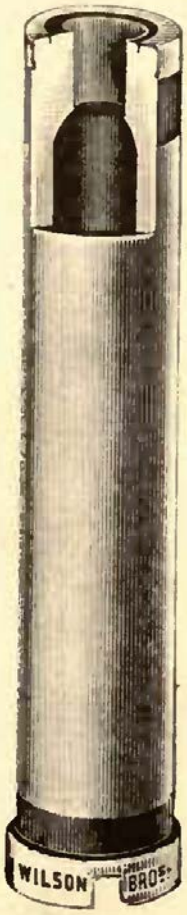

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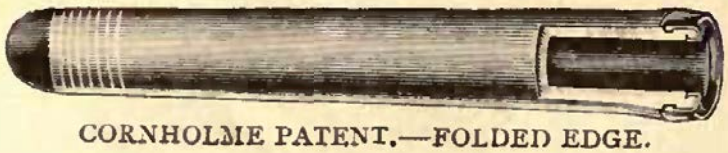

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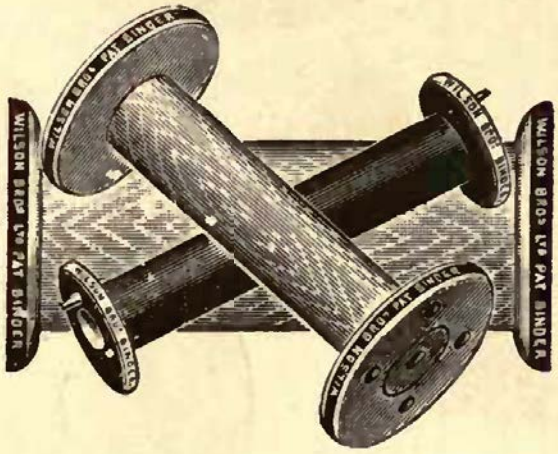

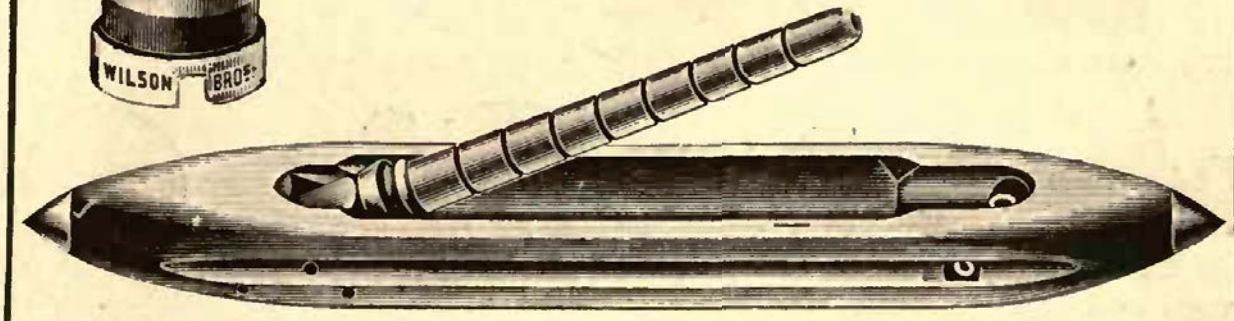

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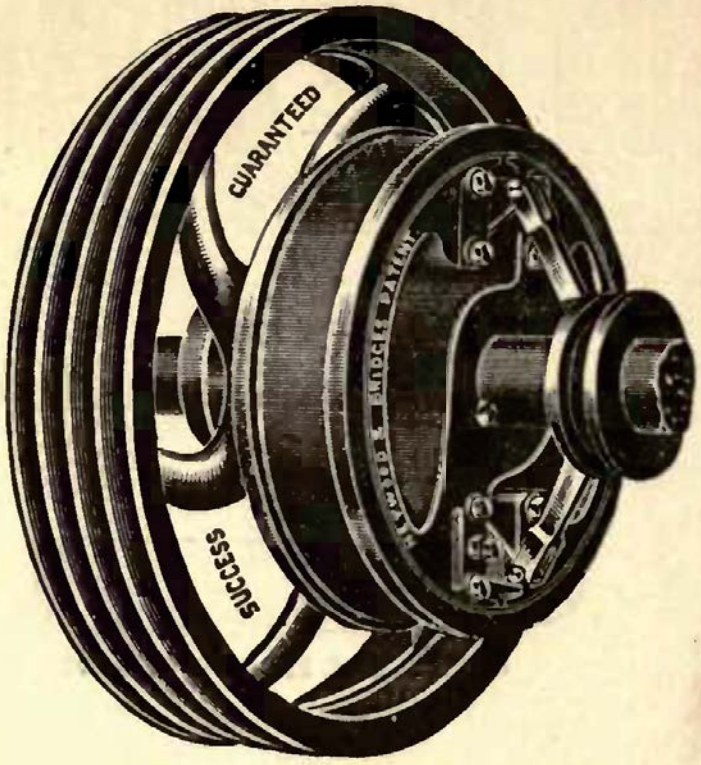

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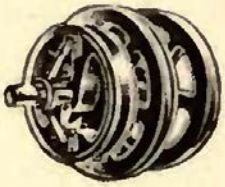

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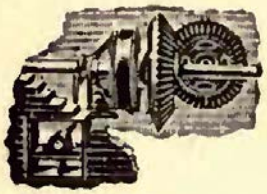

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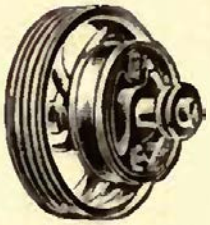

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